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INHERITANCE OF DWARF BRANCHING HABIT IN A NEW VARIETY OF SWEET CLOVER AND ITS POTENTIAL ECONOMIC VALUE IN BREEDING.

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During the last few years the writer has been experimenting with a new type of white flowered biennial sweet clover. Several strains, which are somewhat different, have been isolated by inbreeding, three of which have been increased and are being tested to determine their relative value as forage crops. These strains have been designated collectively as "Alpha" sweet clover and eventually one of them will be selected to bear the variety name.†

A dwarf white flowered biennial sweet clover plant was discovered also by Sigfusson at the Dominion Experimental Farm at Brandon, Manitoba. The writer has had some plants of this strain in the breeding nursery and found that they resemble very closely one of the smallest dwarf types referred to in this paper. Elders (*2*) reported that the Brandon dwarf behaved as a simple recessive to common sweet clover.

Plants of the Alpha type possess certain distinctive characters which make them very different from common sweet clover. They are only about one-half as tall as common white flowered sweet clover, very much finer stemmed and more leafy. The most characteristic feature is their ability to produce numerous branches from crown buds, so that a single spaced plant may have 50 to 100 or more stalks as compared with 5 to 10 for the common sort. The numerous stems are correspondingly small in diameter producing a fine leafy growth that bears a strong resemblance to alfalfa, especially during the first, and early part of the second season. On the other hand, they resemble common white flowered sweet clover in biennial habit of growth and produce flowers, pods and seeds which are indistinguishable from the latter.

Since all plants of Alpha sweet clover possess the dwarf branching habit and since they hybridize freely with common sweet clover, a study was undertaken to determine the mode of inheritance of this growth habit complex which may be designated as the "Alpha" character. Apart from the interest which attaches to an investigation of the mode of inheritance, the study may have considerable economic importance. It has been demonstrated that sweet clover varieties sometimes exhibit marked regional adaptation, so that an understanding of the behavior of the Alpha character in crosses would be advantageous in any attempt to breed a locally adapted strain which would possess this dwarf branching habit of growth.

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†Strain No. 1 has been licensed recently under the variety name "Alpha".

This paper sets forth the results which were obtained in several crosses which were studied between different forms of Alpha sweet clover and the Arctic variety of common sweet clover. The latter is a mid-tall early maturing variety of common white flowered biennial sweet clover that has found much favor in Western Canada.

Origin of Alpha Sweet Clover

In 1924, certain peculiar sweet clover plants were found in a field of Arctic sweet clover on the Field Husbandry seed farm at Saskatoon. The first plant observed was obviously a Melilot but curiously different from typical sweet clover in its flowering parts. The plant was also sterile. This discovery led to a search of the entire eight acre field. In all, forty aberrant plants were found, only six of which were fully fertile. Most of the others were completely sterile or produced only a few seeds.

Figure 1. Two plants from seed of the same parent showing the marked contrast between one type of Alpha sweet clover (left) and a plant of the typical sweet clover type (right).

Figure 2. Two plants from seed of the same parent showing the marked contrast between one type of Alpha sweet clover (left) and a plant of the typical sweet clover type (right).

Eight of the most fertile plants were selected for study and six of them produced two distinct types, one group of plants being similar to typical white sweet clover, the other being characterized by shorter growth, greater leafiness and much more numerous and finer stems. Some of the original

aberrant and alfalfa-like plants derived from them were described with illustrations in an article which was published in *Scientific Agriculture* (*3*). Two other articles describing the nature and behavior of the plants appeared subsequently in the same journal (*4, 6*). More recently, an extended account (*5*) was published of the origin and breeding of the Alpha variety together with observations and determinations on some important characters in relation to its agricultural value.

Preliminary Observations

At first, it was assumed that the typical and Alpha sweet clover forms which appeared in the progenies of the original aberrant plants were the result of Mendelian segregation but further study showed natural crossing to be the correct explanation, the Alpha plants being homozygous for recessive factors and the typical sweet clover being F_1 hybrids resulting from natural crossing. This explanation was shown to be the correct one by selfing both types and growing progenies of plants from each. The Alpha plants produced only plants with the same dwarf branched character, although variable in many other respects, while a majority of the selfed typical sweet clover plants gave progenies which again exhibited the two types. Table 1 gives the numbers of Alpha and typical sweet clover plants in each of eleven such progenies which descended from different original aberrants. It is obvious that the figures approach a 3 : 1 ratio. When the hypothesis of a single factor difference is tested by the χ^2 method, a value of 9.65 is obtained for $n = 11$ indicating that the deviations do not exceed expectation.

Table 1.—*Numbers of Alpha and typical sweet clover plants grown from seed obtained by selfing typical sweet clover plants produced from seed of the original aberrants.*

Family No.	1	2	3	4	5	6	7	8	9	10	11
No. of plants sweet clover type	31	46	36	16	27	23	20	24	22	21	25
No. of plants Alpha type	13	9	7	3	7	10	7	14	6	5	8

Although the information thus obtained indicated that the "Alpha" character was conditioned by a single genetic factor, the parentage was not sufficiently controlled or the numbers large enough to warrant definite conclusions. A special experiment, therefore, was designed for the purpose of obtaining reliable results on the mode of inheritance of the character in question.

Plan of Experiment

The first essential before crossing plants of common sweet clover with the Alpha type was to obtain strains of the latter which were known to breed true for the dwarf branching character. This was accomplished by artificially selfing Alpha plants for two consecutive generations. Care was taken to select plants which were descended from different original aberrants. Alpha-type plants were then taken from these second generation selfed lines and transplanted in the spring of the year into a field of Arctic sweet clover. Each Alpha plant was placed at a considerable distance from any other and each

was surrounded on all sides for several yards by a solid growth of common sweet clover. After the plants had come to maturity, seed from the Alpha plants was carefully harvested by hand. In this way, it was expected that natural hybrids would be obtained without the labor of making artificial crosses. At the same time some knowledge could be gained of the extent of natural crossing under optimum conditions for this to occur.

Preliminary observations described above indicated that natural hybrids could be detected with certainty since the typical sweet clover habit of growth appeared to be completely dominant. Moreover, seed from Alpha plants which were the result of self-fertilization, could only produce Alpha-like individuals because the parent plants were from second generation selfed lines that had come true for this character.

These expectations were fulfilled when seedlings were started in the greenhouse and grown as spaced plants in the field, both typical sweet clover and Alpha-type plants appearing. Roots of typical sweet clover plants (F_1 hybrids) were dug in the fall of the year and matured under electric lights in a greenhouse which was screened to exclude insects. Seed from 43 of these plants were started in the greenhouse and the seedlings transplanted into the field about June 1st. These F_2 families were grown in rows three feet apart, the plants being spaced two feet apart in the row. This nursery consisted of 3352 plants and occupied almost an acre of land. Counts were made about September 1st, 1930, to determine the numbers of Alpha-type sweet clover plants.

Natural Crossing Between "Alpha" Type and Common Sweet Clover Plants

The amount of natural crossing in per cent which had occurred in the field between Alpha plants and surrounding plants of the Arctic variety is given in table 2.

Table 2.—*Extent of natural crossing between single plants of Alpha sweet clover, each surrounded by common sweet clover plants of the Arctic variety.*

Strain No. of "Alpha" type parent.	Number of "Alpha" type.	Number of typical sweet clover type.	Natural crossing in per cent.
S-26-1-1	78	84	52
S 26-1-2	26	46	64
S-26-1-3	35	36	57
S-26-2-1	31	38	55
S-26-2-4	21	4	16
S-26-2 5	78	59	43
S-26-5-1	24	27	53
S-26-10-1	69	47	46
S-26-12-1	16	35	69
S-26-13-1	11	36	76
S-26-13-2	46	111	61
S-26-13-3	49	73	60
S-26-14-1	68	124	68
Total	552	720	
Average			57

The average amount of natural crossing for all strains was about 57 per cent. All but three plants were more than 50 per cent cross-pollinated. Conversely, 43 per cent of the seeds from the Alpha plants resulted from self-fertilization. These results indicate both a high degree of inter-fertility for the two types of sweet clover under consideration and also a strong tendency for Alpha-type plants to reproduce by self-fertilization.

It would be desirable to know the degree of natural crossing that takes place between varieties of the white flowered species of sweet clover when grown in close proximity to one another, but such a determination would be hard to make because of the difficulty of recognizing natural hybrids. When Alpha sweet clover is used as one of the parents this becomes possible. The amount of natural crossing between varieties and strains of common sweet clover will doubtless vary greatly and cross-pollination between common and Alpha clover may be more or less frequent than between plants of common sweet clover varieties. Nevertheless, the average figure of 57 per cent may be a fair indication of what actually takes place. At any rate, it is the best estimate available at the present time.

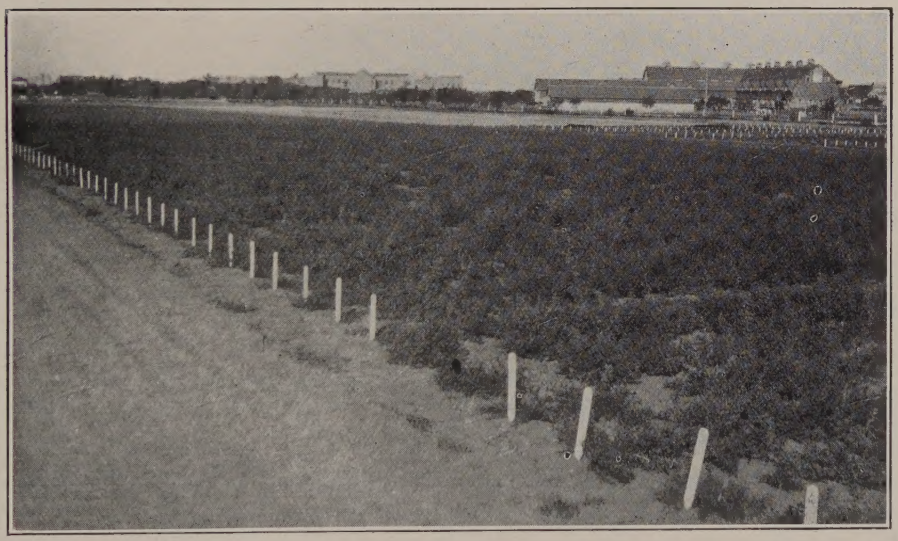

Figure 3. Sweet clover nursery, 1930, consisting of F_2 families of Alpha × Arctic.

Inheritance of the "Alpha" Character

Forty-three F_2 families with an average of 78 plants each, were studied toward the end of the first season's growth to determine the type of Mendelian segregation which had taken place. No difficulty was experienced in distinguishing between Alpha and typical sweet clover plants and no plants of intermediate type were observed. The typical sweet clover growth habit appeared to be completely dominant over the dwarf branching type. The results indicate that the latter is dependent for expression on a single factor difference.

Since there are several very distinct strains of the dwarf branching type which have been isolated from different parent plants by inbreeding, it

is quite possible that two or more of these carry different simple recessive factors for dwarfness. Several of these strains are so different in appearance that tests of identity for the genetic factors could have been made. This has not yet been done, but since a single factor difference is indicated in all of the crosses, the data have been treated statistically as if the same pair of determiners are involved in all cases.

In table 3 are given the observed frequencies of common and Alpha type plants which were found in each of the F_2 families. The agreement with expectation on the basis of a 3 : 1 ratio was tested individually and collectively by means of the χ^2 distribution. In no case was the discrepancy found to be unreasonably large. Total χ^2 was 32.5 for n = 43. Since the χ^2 table has not been calculated beyond n = 30, the goodness of fit was obtained by substituting in the formula $(\sqrt{2\chi^2} - \sqrt{2n - 1})$ (*1*). If this quantity is greater than 2, the value of χ^2 is not in accordance with expectation. In this case, it is less than 1.2 which indicates that the agreement is very good.

TABLE 3.—*Observed frequencies in F_2 families of a cross between sweet clover plants of the Alpha and Arctic varieties.*

Number of family	Common type plants	Alpha type plants	Number of family	Common type plants	Alpha type plants
1–1–1	65	24	2–6–3	50	13
1–1–2	61	22	2–6–4	67	26
1–1–3	30	16	2–6–5	65	25
1–1–4	69	16	2–6–6	50	14
1–2–5	68	22	2–6–7	49	15
1–3–1	67	22	5–1–1	25	8
1–3–2	76	18	5–1–2	58	20
1–3–3	71	19	10–1–1	33	7
1–3–4	65	27	10–1–2	59	11
1–3–5	58	24	10–1–3	56	19
1–3–6	59	16	10–1–4	62	24
1–7–1	61	25	10–1–5	70	21
1–7–2	66	16	10–1–6	63	24
2–1–1	54	15	10–2–1	59	24
2–1–2	34	10	10–2–2	62	22
2–1–3	75	14	10–2–3	70	21
2–5–1	53	18	10–2–4	68	24
2–5–2	70	14	14–1–1	26	13
2–5–3	58	21	14–1–2	71	14
2–5–4	55	23	14–1–3	74	18
2–6–1	71	19	14–1–4	68	25
2–6–2	56	16			

Since a fairly large number of χ^2 values are available, a somewhat more exacting test may be made by comparing their observed distribution with that expected. This has been done in table 4 by distributing the observed values of χ^2 among the classes bounded by values given in the χ^2 table (*1*, *7*). The χ^2 test has then been used to test the agreement of the observed and expected frequencies. Here χ^2 has a value of 5.1 for n = 9, and the χ^2 table shows that P is between 0.80 and 0.90. It is very evident that the deviation from expectation is not significant since it is exceeded by chance in 80 to 90 per cent of the cases.

TABLE 4.—*Test of agreement for the observed distribution of χ^2 values with expected frequencies in 43 F_2 families of a cross between Alpha and Arctic sweet clover.*

χ^2	P	Expected frequency E	Observed frequency O	O-E	$(O-E)^2$	$\frac{(O-E)^2}{E}$
.0000	1.00	.43				
.0002	.99	.43				
.0006	.98	1.29	1	− .29	.0841	.0652
.0039	.95	2.15	4	1.85	3.4225	1.5918
.0158	.90	4.30	2	−2.30	5.2900	1.2303
.0642	.80	4.30	3	−1.30	1.6900	.3930
.148	.70	8.60	11	2.40	5.7600	.6697
.455	.50	8.60	10	1.40	1.9600	.2279
1.074	.30	4.30	5	.70	.4900	.1139
1.642	.20	4.30	3	−1.30	1.6900	.3930
2.706	.10	.15	3	.85	.7225	.3360
3.841	.05	1.29	1	− .29	.0841	.0651
5.412	.02	.43				
6.635	.01	.43				

χ^2 = 5.0859 n = 9 P = between 0.80 and 0.90

EXPRESSION OF THE "ALPHA" CHARACTER

In making the genetic analysis of F_2 families in Alpha × Arctic sweet clover crosses, it was important that the counts should be obtained at a time when the two types could be distinguished with accuracy. This involves the question as to the stage of growth at which the Alpha character becomes expressed. Until the inheritance study was undertaken, it was generally assumed that Alpha-type plants could be identified as such when they were quite young. Segregating lines almost invariably exhibit clearly the two types when the small plants are growing in the greenhouse flats before they have been transplanted into the field. Although scores of such lines had been grown, no careful checkup had been made to determine whether the relative numbers of the two types of plants, as obtained at an early stage of growth in the greenhouse, corresponded with the numbers which were found in the field at the end of the first season's growth. Determinations made in the fall, however, always were found to be practically identical with those in the second year of growth.

In order, therefore, to make sure of reliable data and also to find out definitely whether greenhouse counts could be depended upon, the numbers of Alpha-type and typical sweet clover type plants were counted at three different times. Two counts were made when the plants were in greenhouse flats and a third in the field about the middle of September when the plants had become large and well developed. At the first count, the seedlings were four to six inches high. The second count was made about ten days later but before they had been clipped back in preparation for transplanting.

A comparison of counts which were made at the three different times showed that the first count had been made too early and that the second count could not be relied upon in all cases to give the true ratio between the two types of plants. Although a large percentage of the Alpha plants could

Figure 4. Single plants of Alpha sweet clover type showing characteristics in the second season of growth.

Figure 5. Second season's growth of Alpha No. 3 sweet clover in a drilled plot, photographed at the time of cutting for hay, July 12, 1929. The numerous fine stems may be seen at the base of the plants.

be recognized when the first count was made, the numbers of this type had considerably increased at the time of the second count. When the fall count in the field was made, the ratio of Alpha and typical sweet clover plants had undergone a further modification. The percentage of Alpha-type plants obtained in the last greenhouse count and fall count are listed in table 5 for comparison.

From the figures presented in table 5 it is evident that the two counts agree fairly well in about 50 per cent of the cases. Too close an agreement must not be expected since the per cent of plants in the fall count was based upon the number of actually living plants in the field as given in the second

column, while in the case of the seedling counts, the per cent of plants was based upon the number of plants in the greenhouse flats. Most of the families lost a few individuals from having been transplanted but the mortality was small except in a few lines where it was relatively large.

TABLE 5.—*Comparison of counts made for Alpha-type plants in F2 families of Alpha X Arctic sweet clover at seedling stage and at the end of the first season's growth.*

Number of family	Total No. of plants in field	Seedling counts in per cent	Fall counts in per cent	Number of family	Total No. of plants in field	Seedling counts in per cent	Fall counts in per cent
1–1–1	89	24.2	26.9	2–6–3	63	25.7	20.6
1–1–2	83	23.4	26.5	2–6–4	93	34.0	27.9
1–1–3	46	17.0	34.8	2–6–5	90	33.3	27.7
1–1–4	85	17.7	18.8	2–6–6	64	20.5	21.8
1–2–5	90	22.5	24.4	2–6–7	64	27.9	23.4
1–3–1	89	14.1	24.7	5–1–1	33	22.2	24.2
1–3–2	94	21.0	19.1	5–1–2	78	2.5	25.6
1–3–3	90	22.5	21.1	10–1–1	40	2.4	17.5
1–3–4	92	29.2	29.2	10–1–2	70	17.4	15.7
1–3–5	82	11.5	29.2	10–1–3	75	26.3	25.3
1–3–6	75	23.4	21.3	10–1–4	86	26.6	27.8
1–7–1	86	20.0	29.0	10–1–5	91	27.3	23.0
1–7–2	82	18.5	19.5	10–1–6	87	27.4	27.5
2–1–1	69	15.2	21.7	10–2–1	83	27.4	28.9
2–1–2	44	17.8	22.7	10–2–2	84	26.4	26.1
2–1–3	89	3.3	15.7	10–2–3	91	26.5	23.0
2–5–1	71	27.5	25.3	10–2–4	92	30.1	26.1
2–5–2	84	21.3	16.6	14–1–1	39	28.5	33.3
2–5–3	79	34.9	26.6	14–1–2	85	30.3	16.4
2–5–4	78	35.1	29.4	14–1–3	92	30.8	19.5
2–6–1	90	65.5	21.1	14–1–4	93	17.8	26.8
2–6–2	72	53.9	22.2				

Of the families which exhibited wide discrepancy, there were those in which the "Alpha" character was not expressed soon enough to be clearly recognized when the last count in the greenhouse was made. This is very evident in families 2-1-3, 5-1-2 and 10-1-1 and to a slightly lesser extent in several others, such as 1-1-3 and 1-3-5. On the other hand, in some lines the plants counted as belonging to the Alpha type in the greenhouse exceeded the number that proved to be such at the end of the season. The best examples of this are lines 2-6-1 and 2-6-2. In these cases it was certainly impossible to distinguish the two types of plants at the early stage. It should be remembered of course, that we were dealing with F_2 populations in which the parent on the side of typical sweet clover in each cross was different and doubtless heterozygous for many characters.

In summing up, therefore, it may be said that, while Alpha-type plants may be recognized as such in the seedling stage in a large per cent of the cases, some of these plants in F_2 families must attain a fair size in the field before they can be classified with certainty. Numerous tests have shown that there is not much chance of error if determinations are made at the end of the first season's growth.

DISCUSSION

Sweet clover has been seriously criticised as a forage crop because of its coarse stemmy habit of growth. This is particularly true under climatic

conditions which favor the growth of red clover and alfalfa. At the same time, its prolific seed production, its biennial habit of growth, its qualities as a soil improving crop and its ability to thrive on a great diversity of soil types, have gained recognition for it as one of the most useful economic plants that has ever been introduced into cultivation.

Alpha sweet clover is still in the experimental stage, but whether or not it is found to be a desirable variety in its present form, it possesses certain qualities that at once appeal to the eye of the lover of good forage and completely disarm the criticism that sweet clover is unsuited for feed because of its coarse fibrous stems. The stems of Alpha sweet clover are much more numerous than is the case with common sweet clover and they are comparable to alfalfa in size and leafiness. The leaves also are less bitter than those of common sweet clover. In seed production it is equal to common sweet clover and probably better, due to the fact that the seed ripens uniformly. Because of its biennial habit of growth, it can be used with advantage in short rotations, and tests have shown that its root development is equal to common sweet clover when both are grown under the same conditions.

In view of the fact that our inheritance study indicates that the Alpha character is transmitted in a very simple manner, at least in crosses with one variety of white flowered biennial sweet clover, it will be possible apparently to make use of it in crosses with varieties of common white flowered sweet clover, which are found to be highly adapted to certain areas. At the present time, some of the best adapted types are too coarse for field cultivation. For hay purposes, it is often the quality and not the yield which determines the choice of varieties which are in use at present. By crossing Alpha plants with large coarse growing but well adapted types of sweet clover, it should be possible to develop varieties that are valuable for hay purposes as well as for pasture, and at the same time, retain those qualities which make the coarser growing varieties suited to a particular environment.

Summary

1. This paper reports the results of an inheritance study in crosses between a variety of typical common white flowered biennial sweet clover known locally as Arctic and a new variety of white flowered biennial sweet clover which is called Alpha.

2. The character complex which consistently differentiated the two varieties which were intercrossed is the fine stemmed, dwarf, branching habit of Alpha sweet clover. This was designated as the "Alpha" character.

3. Forty-three F_2 families, with an average of 78 plants in each, were grown. The number of Alpha and typical sweet clover-like plants were determined in the fall of the first season's growth. The results gave a very good fit to a 3 : 1 ratio, indicating that the "Alpha" character is dependent upon a single factor difference.

4. The typical common sweet clover type of growth was dominant to the Alpha type of growth.

5. While the majority of Alpha-type plants in F_2 progenies could be recognized as such when growing in greenhouse flats before transplanting,

the two types of plants could not be classified accurately until they had attained considerable size in the field. Field counts were made toward the end of the first season.

6. The advantage which may follow from using plants which possess the Alpha character in crosses with well adapted but coarse growing varieties was emphasized. By this means, it may be possible to improve greatly the quality of sweet clover hay.

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INHERITANCE OF THE DWARF BRANCHING HABIT IN SWEET CLOVER *

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Since certain dwarf branching types of white sweet clover have aroused considerable interest within recent years, a genetical study of these forms was undertaken at the University of Wisconsin.

REVIEW OF LITERATURE

In 1924 Kirk (*6*) discovered some aberrant plants in Arctic, an early-flowering variety of common white sweet clover. Some of these plants were completely sterile, others nearly so, and a few forms were fully fertile. Kirk (*7*) describes them as follows: "In habit of growth the abnormalities included constricted branching, tufted foliage, numerous primary stalks and well developed, much-branched crowns. The inflorescence was sometimes characterized by shortened racemes, bunched flower clusters or elongated flower pedicels. In one case flower clusters were produced on branches growing out from what would normally be the axis of the raceme forming an inflorescence pyramidal in shape and feathery in appearance. The pods when produced were usually normal in appearance but in a few cases they were long, narrow, slightly coiled and with four to five ovules in each."

Kirk (*7*) noted that progenies from each of the fertile plants segregated into two main types one of which is like typical white-flowered sweet clover while the other is characterized by a shorter, finer growth, numerous leaf stalks and a much-branched crown. Each parent plant produced a different type of aberrant progeny. These aberrant types differ quite markedly from biennial white sweet clover, the differences consisting chiefly in the numerous shorter, leafy stems which develop from the multiple buds at the crowns. According to Kirk and Davidson (*9*) there is great variability between the strains in respect to time of maturity and disease resistance. Some strains appear to have a lower coumarin content than common sweet clover and are therefore less bitter. By inbreeding and selection Kirk (*8*) developed a new variety consisting of dwarf branching plants which he has named "Alpha" sweet clover.

At the Dominion Experimental Farm at Brandon, Manitoba, Canada, Sigfusson in 1924 discovered a dwarf sweet clover plant. This is a true biennial plant but produces a low, bushy growth during the first season in contrast to the tall, spreading, somewhat coarse growth of normal sweet clover, and in the second season about thirty to forty fine stems grow from a branching crown to a height of about thirty inches. The plant flowers normally and produces seed freely. Elders (*3*) found that this habit of growth is inherited as a simple recessive. Probably the dwarf originated by mutation of a single genetic factor.

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Materials and Methods

Various strains of dwarf branching sweet clover obtained from Dr. L. E. Kirk of the University of Saskatchewan were grown in the greenhouse at the University of Alberta during the winter of 1928-29. These strains were intercrossed among themselves and also crossed with Arctic sweet clover. The hybrid seed thus obtained was planted in the greenhouse at the University of Wisconsin in the spring of 1929 and later transplanted to the field. In the fall the plants were brought back to the greenhouse. In this way self-fertilized seed was obtained from these F_1 plants in the spring of 1930. As "hard" seeds are quite common in sweet clover this seed was treated with concentrated sulphuric acid for thirty minutes, washed in water, then germinated on blotting paper, and later transferred to the greenhouse. When about six weeks old the material was transplanted to the field in rows forty-two inches apart and spaced four inches in the row.

Experimental Results

Results from Crossing Dwarf Branching and Tall Sweet Clover

F_2 progenies were studied towards the end of the first year's growth. Table 1 shows the results obtained in crosses between a number of dwarf branching strains, and Arctic, the variety in which they were discovered. In each case the F_1 plant was tall like the Arctic parent.

Table 1.—*Observed and expected frequencies in F2 families of a cross between sweet clover plants of the dwarf branching and tall types.*

No. of family	Observed		Expected (on 3:1 basis)		Dev. in numbers	P. E.	Dev. / P. E.
	Tall plants	Dwarf branching plants	Tall plants	Dwarf branching plants			
1–1–1	62	18	60.0	20.0	2.0	2.61	less than 1
2–6–1	341	50	293.25	97.75	47.75	5.78	8.3
2–6–1	419	62	360.75	120.25	58.25	6.41	9.1
3–1–1	168	57	168.75	56.25	0.75	4.38	less than 1
3–1–2	490	167	492.75	164.25	2.75	7.49	less than 1
4–1–1	330	124	340.5	113.5	10.5	6.22	1.7
5–1–1	189	52	180.75	60.25	8.25	4.23	1.8
6–3–1	30	8	28.5	9.5	1.5	1.80	less than 1
6–3–1	67	21	66 0	22.0	1.0	2.74	less than 1
6–3–1	194	66	195.0	65.0	1.0	4.71	less than 1
10–1–1	216	84	225.0	75.0	9.0	5.06	1.8
14–1–1	150	46	147.0	49.0	3.0	4.09	less than 1

With the exception of the two progenies obtained by crossing 2-6-1 with Arctic, all the progenies show a reasonably close fit to a 3:1 ratio. As described later, the two exceptional cases result from linkage complications. In each instance the results may be explained by assuming the dwarf branching type differs from the Arctic by a single factor, the dwarf being recessive.

Results from Intercrossing Various Dwarf Branching Strains

In the following crosses of various dwarf branching strains only dwarf plants were obtained in the F_1 and the F_2.

1-4-1 × 6-6-1
2-1-2 × 1-4-1
2-1-2 × 4-1-1
2-1-2 × 6-3-1
2-1-2 × 6-6-1
2-1-2 × 11-1-1
2-1-2 × 12-1-1
2-6-1 × 1-4-1
2-6-1 × 4-1-1
2-6-1 × 6-3-1
2-6-1 × 6-6-1
2-6-1 × 11-1-1
12-1-1 × 13-2-2

This indicates that strains 1-4-1, 2-1-2, 2-6-1, 4-1-1, 6-3-1, 6-6-1, 11-1-1, 12-1-1 and 13-2-2 carry the same factor for the dwarf branching character.

In the following crosses the F_1 plant was tall like the Arctic parent and both tall and dwarf segregates were secured in the F_2:

2-1-2 × 3-1-2
1-4-2 × 5-1-1
2-8-1 × 5-1-1

These crosses show that strains 3-1-2 and 5-1-1 carry a different gene for dwarfing from that carried by the other dwarf branching strains which have been investigated. These two strains may be distinguished from the other dwarf strains by their more clumped, less spreading habit of growth during the first year. It may be assumed that strains 3 and 5 carry one recessive gene which has been named "bunched dwarf" (*bd*), while strains 1, 2, 4, 6, 11, 12 and 13 carry a different recessive gene, called "spreading dwarf" (*sd*).

In crosses between bunched dwarf and spreading dwarf it has not been found possible to distinguish with certainty the two dwarf types in the F_2 at the end of the first year's growth. However, if the term "dwarf" is retained to designate both bunched dwarf and spreading dwarf types, one would expect, in the F_2, a ratio of 9 tall, Arctic-like plants to 7 dwarf plants. The results obtained are shown in Table 2.

TABLE 2.—*Observed and expected frequencies (on 9:7 basis) in F2 families of a cross between sweet clover plants of the bunched dwarf and spreading dwarf types.*

Cross	Observed		Expected (on 9:7 basis)		Dev. in numbers	P. E.	Dev. / P. E.
	Tall plants	Dwarf branching plants	Tall plants	Dwarf branching plants			
2-1-2 x 3-1-2	47	32	44.5	34.5	2.5	3.16	less than 1
1-4-2 x 5-1-1	256	135	220 0	171 0	36 0	6 62	5 4
1-4-2 x 5-1-1	29	21	28.1	21 9	0.9	2 37	less than 1
2-8-1 x 5-1-1	460	297	425.8	331.2	34.2	9.21	3.7
Total for all progenies	792	485	718.3	558.7	73.7	11.6	6.4

The results given in Table 2 cannot be considered a satisfactory fit to a 9:7 ratio. A clue to the cause of the discrepancy is furnished by the occurrence of several peculiar dwarf plants in the 2-8-1 × 5-1-1 cross. It seems probable that these few plants represent the double recessive class

and are homozygous for both the bunched dwarf and the spreading dwarf characters. Since these double recessive dwarfs occurred in less than 1 in 16 of the F_2 plants in the 2-8-1 × 5-1-1 cross and were not observed in the other crosses it would appear that the presence of both dwarf factors has a weakening effect so that very few, if any, plants of this genotype survive. Owing to the elimination of these double recessive dwarfs the expected 9:7 ratio is modified to a 9:6 ratio. Table 3 shows the results obtained when a 9:6 ratio is used for calculating the expected results and the double recessive dwarfs (9 in number) are eliminated from the F_2 progeny in which they occur.

TABLE 3.—*Observed and expected frequencies (on 9:6 basis) in F2 families of a cross between sweet clover plants of the bunched dwarf and spreading dwarf types.*

Cross	Observed		Expected (on 9:6 basis)		Dev. in numbers	P. E.	Dev./P. E.
	Tall plants	Dwarf branching plants	Tall plants	Dwarf branching plants			
2-1-2 x 3-1-2	47	32	47.4	31.6	0.4	2.83	less than 1
1-4-2 x 5-1-1	256	135	234.6	156.4	21.4	6.29	3.4
1-4-2 x 5-1-1	29	21	30.0	20.0	1.0	2.25	less than 1
2-8-1 x 5-1-1	460	288	448.8	299.2	11.2	8.67	1.3
Total for all progenies	792	476	760.8	507.2	31.2	11.16	2.8

Table 3 indicates that the F_2 progenies fit a 9:6 ratio fairly closely and this ratio can be explained by assuming that the double recessive class is entirely, or almost entirely, eliminated by natural means. Suitable crosses are to be made to determine whether the few double recessive dwarfs observed are actually double recessive. In any event the conclusion seems justified that at least two types of dwarfs occur.

The possibility remains that there may be more than two different genes for dwarfing. Strains 3 and 5, which, it has been assumed, carry the bunched dwarf factor, have not been crossed with each other. Until this cross has been obtained it will not be definitely established whether they carry the same gene for dwarfing or not. It is shown, however, that neither carries the gene for spreading dwarf.

Inheritance of Pale Green

Seedlings which are pale green in colour occurred in a number of F_2 progenies, as shown in Table 4. All F_1 plants were normal green.

In each cross enumerated in Table 4 either the 6-3-1 or 2-6-1 is one of the parents. This suggests that the 6-3-1 plant and the 2-6-1 plant used in the hybridization experiments were heterozygous for pale green .

With the exception of the 2-6-1 × 6-3-1 cross all the F_2 progenies give a close fit to a 3:1 ratio or show a deficiency in the recessive class. This shortage in the number of pale green seedlings obtained can be explained by the lack of vigor of the pale green seedlings and either the failure of a large proportion of the seeds of the pale green class to germinate or death

of the plants shortly after germination. When a counted number of seeds was planted a sufficient number failed to develop to account for the shortage in number of pale green seedlings. The weakness of the pale green seedlings is shown by the death of a number of them in the greenhouse before transplanting. On being transferred to the field almost all the pale green seedlings died while practically all the normal green plants survived. The conclusion seems justified that these progenies represent a modified 3:1 ratio, with a deficiency in the number of pale green seedlings owing to the recessive factor being semi-lethal.

TABLE 4.—*Observed and expected frquencies in F₂ families segregating for normal green and pale green seedlings.*

Cross	Observed		Expected (On 3:1 basis)		Dev. in numbers	P. E.	Dev. / P. E.
	Normal green	Pale green	Normal green	Pale green			
Arctic x 6-3-1	419	116	401.25	133.75	17.75	6.76	2.6
2-1-2 x 6-3-1	69	28	24.25	72.75	2.25	2.88	less than 1
2-6-1 x Arctic	411	49	345.0	115.0	66.0	6.26	10.5
2-6-1 x Arctic	458	69	395.25	131.75	62.75	6.70	9.4
2-6-1 x 4-1-1	325	115	330.0	110.0	5.0	6.13	less than 1
2-6-1 x 6-3-1	49	43	69.0	23.0	20.0	2.80	7.1

The excess in number of pale green seedlings in the 2-6-1 × 6-3-1 cross results from two different pale green factors being involved. If the 2-6-1 parent plant is homozygous for one factor for pale green (pg_1), and the 6-3-1 parent is heterozygous for a different factor for pale green (pg_2), independent of the first, it would be expected that in 25 per cent of the F_2 progenies only normal green plants would be obtained, in 50 per cent a 3:1 ratio would result and in the remaining 25 per cent a 9:7 ratio would be secured. Only two F_2 progenies were studied from this cross. One produced only normal green plants, the other is reported in Table 4. The latter gives a very poor fit for a 3:1 ratio, but fits a 9:7 ratio quite satisfactorily.

The presence of two different factors for pale green, pg_1 and pg_2, is confirmed by a consideration of their linkage relations. In Table 1 the results secured by crossing 2-6-1 × Arctic and Arctic × 6-3-1 are shown. The latter ratio fits a 3:1 ratio but the former does not as there is an excess of tall Arctic-like plants. This indicates that pg_1 is linked with spreading dwarf and the deficiency in spreading dwarf plants results from the deficiency in the pale green class (Table 4). Spreading dwarf and pg_2, however, are inherited independently. The results obtained in the 2-6-1 × Arctic cross can be accounted for by assuming that about 21 per cent crossing-over takes place between *sd* and pg_1. The amount of crossing-over has been estimated by a modification of Emerson's method (4) and has been derived from the normal green plants only, since most of the pale green plants died before they could be classified for habit of growth.

Origin of Dwarf Branching Types of Sweet Clover

Kirk (6) has suggested that these dwarf branching types of sweet clover may have arisen as natural crosses between sweet clover and alfalfa.

Evidence already presented in this paper, however, shows that bunched dwarf and spreading dwarf are each conditioned by a single recessive gene, indicating that these forms have probably arisen as simple gene mutations.

Additional evidence supporting the view that these dwarfs have arisen by mutation, and not by hybridization, has been obtained. At the University of Alberta and also at the University of Wisconsin attempts have been made to cross Grimm alfalfa and white sweet clover, but these attempts have invariably failed. Other mutant dwarf branching types are known. One has been reported by Elders (*3*). Dr. R. A. Brink has kindly given permission to cite an instance of some dwarf plants which he has discovered in a self-fertilized line of common white sweet clover. In this case self-fertilized seed was obtained in the green-house and the aberrant plants could not have arisen through intergeneric hybridization.

Castetter (*1*) has reported the haploid number of chromosomes for *Melilotus alba* as eight. According to Elders (*2*) and Fryer (*5*) the diploid number for this species is sixteen while in *Medicago sativa* it is thirty-two. Root tip counts of the dwarf branching sweet clover made by the present writer show that unquestionably they possess sixteen chromosomes, the normal number for *Melilotus alba*. The chromosome number found in the dwarf plants supports the view that they are mutant forms but does not necessarily preclude the possibility that they are sweet clover×alfalfa hybrids since segregates with sixteen chromosomes might be derived from such a cross. A study is now under way to show whether or not the chromosome pairs are morphologically similar to those of common white sweet clover but it has not yet been completed. Smear preparations of the reduction divisions in the dwarf branching plants failed to show any irregularities in chromosomal behavior. The linkage of the genes pale green 1, (pg_1) and spreading dwarf (*sd*) with a small amount of crossing-over, indicates that the chromosome pair represented by this linkage group behaves in a normal manner.

The presence of sterility in some of the original plants discovered by Kirk (*6*) may be accounted for by assuming that, through inbreeding, he uncovered in the Arctic variety a number of recessive factors for sterility as well as dwarfing. Through natural and artificial selection these factors for sterility have been eliminated from the dwarf branching strains. Seed from these original plants gave progenies which segregated for tallness and dwarfness (*7*) but this appears to have been the result of natural crossing and not Mendelian segregation.

Pollen from all F_1 hybrid plants was stained with iodine solution and examined microscopically but no evidence of aborted pollen grains was obtained. The pollen appeared quite normal in all respects. Unfortunately efforts to germinate sweet clover pollen on artificial media proved unsuccessful.

The evidence appears to be conclusive that the dwarf branching forms studied in this paper have originated through mutation and not through intergeneric hybridization.

ACKNOWLEDGEMENTS

The author is indebted to Dr. L. E. Kirk of the University of Saskatchewan for kindly providing seed of the strains of *Melilotus alba* used in this

study and to Dr. R. Newton of the University of Alberta, for providing greenhouse facilities for growing and hybridizing these strains during the winter of 1928-29. Especially is the author indebted to Dr. R. A. Brink, of the Department of Genetics at the University of Wisconsin, who first suggested the problem and under whose direction the work has been carried out.

Summary

1. The dwarf branching habit in the strains studied results from one or the other of two genes, bunched dwarf (*bd*) and spreading dwarf (*sd*). Both are recessive to normal sweet clover.
2. Two genes, pg_1 and pg_2, for the development of the pale green seedling character are described.
3. Pg_1 is linked with *sd*. About 21 per cent crossing-over occurs between these two genes.
4. Evidence is presented to show that the dwarf branching strains have arisen from gene mutations and not from a cross between Arctic sweet clover and alfalfa.

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BREEDING EXPERIMENTS WITH THE CUCUMBER (*Cucumis sativus. L*).*

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Introduction

Much hybridization work with the cucumber has been carried on in an attempt to produce varieties that would be more particularly adapted to growing under glass in North America. The long smooth forcing cucumber of England does not seem to be the most desirable type for market purposes in Canada or the United States; neither do the ordinary American White Spine varieties. Growers and seedsmen, with the hope of obtaining varieties better suited to their needs, have done most of this hybridizing work, using varieties of these two types as parents but they seem to have paid little or no attention to the inheritance of characters. The writer, in an attempt to add to the rather meagre data on inheritance in this plant, undertook these breeding experiments an account of which is given in this article.

Review of Previous Work

Probably the earliest recorded data in North America on the inheritance of characters in the cucumber is a note by Wellington on the inheritance of spine colour and other fruit characters which appeared in Science in 1913. Wellington crossed a variety of White Spine type with a black spine English Forcing variety (Richard's Invincible) using the latter as the pollen parent and obtained, as he says, "a type of fruit apparently intermediate in size and in number and prominence of the spines, with the exception that all the spines were black like the paternal parent". He further states that "In the F_2 generation, of the twenty plants grown, fifteen bore black spines and five white", and that "The inheritance of the colour of the spines apparently follows the simple Mendelian segregation". In recent correspondence Mr. Wellington (now at the Geneva Experiment Station) says that this conclusion as to Mendelian segregation of spine color was later confirmed by Hayes, at the Minnesota Agricultural Experiment Station, where he himself had done the original work. At the Connecticut Agricultural Experiment Station Hayes and Jones (1916) studied first generation crosses of several varieties of cucumber. These crosses, in all except one case, showed heterosis by increase in the size of fruits and also in the number of fruits formed. The one cross that failed to show hybrid vigor was between two varieties that were almost identical in size and form and apparently very similar genetically.

At our own Vineland Station, Reeves (1918) made crosses between the English Forcing type (Telegraph variety) and the White Spine type (Early White Spine and Fordhook Famous varieties). He found that a few plants formed about 20 per cent. of their fruit without pollination, and also that the F_1 fruits were intermediate in type.

Strong (1921) also reports on breeding work carried on at the Vineland Station. A brief account is given of the origin and development of a new type of cucumber suitable for growing under glass. It resulted from a cross

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between Sutton's Everyday, Fiske's White Spine and Princess and from amongst a number of strains one was selected as suitable for distribution for trial and was given the name Hescrow. During the progress of this work it was observed that 'black' spine was dominant to 'white'.

Rosa (1928) working at the California Agricultural Experiment Station, made a study of the inheritance of flower types in *Cucumis* and *Citrullus*. In-so-far as *Cucumis sativus* is concerned, he found that while the monoecious condition was usual, one variety (the Lemon cucumber) had hermaphroditic flowers in place of the pistillate. He made two crosses between monoecious varieties and the Lemon type and states that, "The F_1 plants always show the pistillate condition to be completely dominant". A rather small F_2 generation segregated into "11 plants bearing pistillate to 5 with hermaphroditic flowers". From his F_1 and F_2 results he came to the conclusion that "the hermaphroditic condition depends upon a single recessive factor".

Clayton (1929) at the Long Island Vegetable Research Station did selection work with the cucumber for resistance to a downy mildew caused by *Pseudoperonospera cubensis* (B. & C.) Rostew. to a bacterial wilt caused by *Bacillus trachciphilus* (E.F.S.) and to mosaic. He found that all lines were equally susceptible to mildew, that numerous lines showed extreme susceptibility to wilt and a few moderate resistance, and also that there were forms decidedly resistant to mosaic as well as many that were extremely susceptible.

Experimental Material

From amongst the many varieties of cucumbers representing various types the writer selected thirty-seven that offered wide diversity in characters. All these varieties were grown for at least one season and some for two or three seasons. From amongst them six were finally selected for the breeding experiments. These six were Vickery Forcing, Sutton's Everyday, Crystal White, Princess, China, and Early Russian and they were used in making the following crosses:— Vickery × Everyday, Crystal White × Vickery, Vickery × Princess, Princess × China, Early Russian × China and Early Russian × Everyday. From six to twelve plants of the F_1 generation of each of these crosses were grown but two crosses only, namely: Crystal White × Vickery and Vickery × Everyday were taken to the F_2 generation. The former was grown principally for observation of the inheritance of colour of the fruit, the parents being respectively white and dark green, while the latter was carried on because in addition to its apparent value for the study of the inheritance of characters it also appeared to have promise from the commercial viewpoint.

All the plants of the variety tests, of the F_1 generation and some of the F_2 plants were grown under glass (as indicated later on in this article) but the bulk of the plants of the F_2 generation were grown outdoors.

Descriptions of Characters

The characters considered in this study are described briefly in the following paragraphs. Fruit shape, however, is not included in this section as it seemed to be due to a combination of several other characters which probably are controlled by numerous factors. Owing to this apparent complexity of the inheritance of fruit shape no definite conclusions are arrived at although

certain data are presented and suggestions made as to the probable mode of inheritance.

Regularity of Internode Lengths. Apart from the few shorter internodes at the lower part of the stem the length of internode on all varieties observed, except one, may be classed as 'regular' i.e. it is fairly uniform over the whole plant. The exception is found in the Early Russian variety. In this the internodes vary very considerably, some being four inches or more in length, others a half-inch or even less, and in extreme cases two nodes may be practically touching so that two leaves appear as if coming from the same place on the stem. These very short internodes were interspersed irregularly among the long ones.

Stem section. The stems of all the varieties studied, with one exception, are 'grooved and ridged', so that the outline of the transverse section is rather irregular (Figure 1, B .& C.). The exception was found in the Early Russian variety, in which the stem is 'smooth, not grooved and ridged', and almost round or elliptical in section (Figure 1, A).

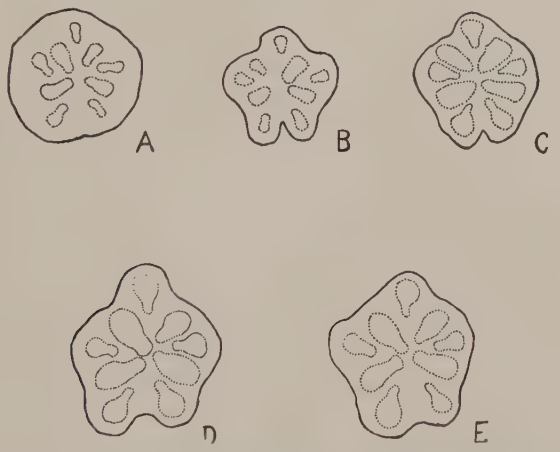

Figure 1. Camera lucida drawings indicative of shape of stem (but not of relative size). A Early Russian, B. Everday, C. China, D. Early Russian by Everyday, E. Early Russian by China.

Leaf size. The size of the leaf varies somewhat on individual plants yet certain varieties or groups of varieties have characteristic size, e.g. Everyday and other English Forcing varieties have large leaves while Early Russian has small leaves and others have leaves of various sizes between these extremes.

Leaf colour. The colour of cucumber leaves varies from very dark green to pale yellowish green with various shades between these extremes. The Vickery variety is typical of the former and China of the latter.

Internode length. Cucumber varieties have a more or less characteristic length of internode, i.e. some have long internodes some short and others intermediate.

Fruiting habits. The cucumber is as a rule monoecious although one variety, the Lemon, is known to produce hermaphroditic flowers. Both types of flower, staminate and pistillate, are borne at the nodes, the former in

clusters, while the latter may be borne singly, in pairs and in clusters of various numbers from three to twelve or more. Of the six varieties used in these experiments, two, China and Crystal White, produce one and only occasionally two pistillate flowers and fruits at a node. For convenience these will be referred to as 'non-clustering'. The four other varieties show different degrees of clustering—Everyday has usually one or two and occasionally three or four fruits at a node, Vickery produces from one to six, while Princess and Early Russian show a greater degree of clustering. The two last mentioned varieties may have as few as one or two fruits, but they usually have a much larger number—up to twelve or more at a node. In these four varieties different degrees of clustering appear to be as characteristic as the lack of clustering in the other two.

Fruit stalk length. Varieties used in this work had a more or less characteristic length of stalk which ranged from .5 inches or less to as much as 3 inches.

Fruit length. Varieties of cucumbers appear to have characteristic lengths of fruit. The short forms range in length from 3 to 6 inches in Early Russian and 8 to 9 inches in Vickery, while the long forms run from 13 to 18 inches in Everyday and 16 to 20 inches in China.

Fruit colour. Green of various shades is the usual colour of the exterior of cucumber fruits at the edible stage, although white or cream is not uncommon. The green shades range from a rather light yellowish green to a dark bluish green, according to variety. In some varieties the green is fairly uniform all over the fruit, while in others it appears as a ground colour which is more or less hidden by a mottling of various shades of yellowish or greyish green. In the varieties studied for colour inheritance one (Crystal White) is white or creamy, another (Everyday) is yellowish green, and a third one (Vickery) is dark bluish green. According to the Ridgeway Colour Chart the colour of Everyday is Spinach Green (Pl. V 29-m GG-Y) but with rather more yellow hues, such as Cerro and Calla Green. In Vickery the predominating colour is Cossack green (Pl. VI. 33-m GY-G) also with a tendency to yellow hues such as Cedar Green. In this variety the colour is somewhat hidden by a dense mottling of lighter greyish or yellowish green.

Fruit mottling. The fruits of some varieties, such as China and Vickery, are more or less covered with a mottling of slightly grey yellowish green which in some cases practically hides the ground colour. Others, such as Everyday and Princess, lack this mottling.

Dullness or glossiness of fruit. All the American varieties under observation had dull skins while the English Forcing varieties had glossy or shiny skins.

Warts. In many varieties the surface of the fruit is more or less irregular by reason of prominences or warts on which are borne the spines. In a few varieties such as Princess, and in many, if not all, of the English Forcing varieties the surface is regular and smooth.

Texture of skin. The skin of the cucumber varieties under observation was found to be 'thick and tough' or 'thin and tender'. The former condition

is characteristic of all varieties except those of the long green English forcing type which have 'thin and tender' skins.

It is quite possible that toughness may be due to thickness and tenderness to thinness of skin, since sections examined under the microscope showed that the thick skins were made up of several layers of epidermal cells while the thin skins appeared to consist of only one layer.

Spine number. There is a marked difference in the number of spines on the fruits of the various types. Varieties of the English Forcing type usually have very few spines (e.g. Everyday), in fact, some might be described as spineless. This, however, would not be strictly correct as even the smoothest have a few spines but they usually disappear very early in the growth of the fruit. Other types, such as Vickery, have many more.

Colour of spines. Cucumber spines consist of two parts, a base more or less round or bulbous and a fine point made up of several cells which surmounts the base. These spines may be located on warts or on the smooth surface of the fruit. In colour, spines may be black or white when mature, although in the young spine colour is not very pronounced. The black appears first as a translucent green which gradually changes to black, first in the fine point and later in the bulbous part (Figure 2). With maturity the colour involves the whole spine. (Note that III B in Figure 2 is not fully mature). In the variety Everyday the black is extremely slow in spreading over the

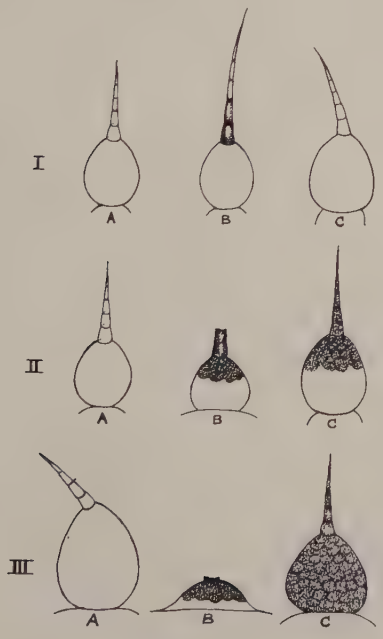

Figure 2

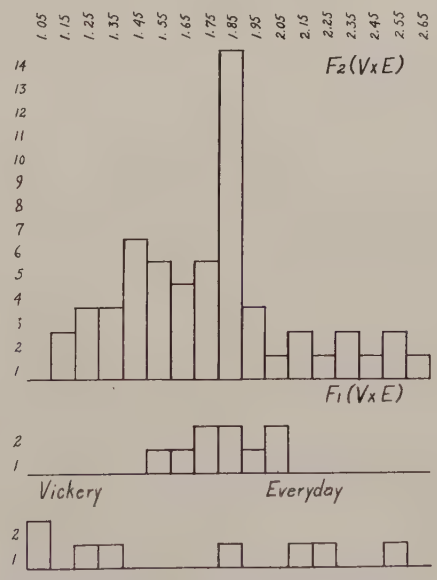

Figure 3

Figure 2. Drawings illustrating the character of the spines. I, II, and III represent successive ages. A. Vickery, B. Everyday, and C. the hybrid.

Figure 3. Diagram illustrating fruit stalk length in two parent varieties, Vickery and Everyday, and their F_1 and F_2 progeny. Number of plants at the side, length in inches above.

base so that even in fully grown fruit it is not completely black but when the fruit is ripe the base is black all over. White spines are almost translucent or clear when very young, but soon change to white.

Size of spines. Spines on the cucumber fruits vary in size from 'large' (Vickery) to 'small' (Everyday) and many varieties have spines of intermediate size. Figure 2.

Flesh colour. The colour of the flesh of the cucumber is quite distinctive in some varieties. Vickery has pure white flesh with a definite demarkation between the colour of the thick dark green skin and the flesh, while Everyday, on the other hand, has flesh of a decided greenish tinge with no distinct demarkation between it and the skin.

Data Obtained from Crosses

The character pairs involved, the crosses made, and results obtained in the F_1 and F_2 generations with a few brief comments are set forth in the following tables. Shape of fruit is not included in these but is discussed briefly on page 339.

Table 1.

Characters	Parents Crossed	F1	F2
Regular and irregular internodes	China × Early Russian	Regular	———
	Everyday × Early Russian	"	———
Grooved and ridged & non-grooved and ridged stems	China × Early Russian	Grooved and ridged	———
	Everyday × Early Russian	"	———
Mottled and non-mottled fruit	Vickery × Everyday	Mottled	(1) 213 mottled to 68 non-mottled
Dull and glossy fruit	Vickery × Everyday	dull	(1) 213 dull 68 glossy
Warty and non-warty fruit	Vickery × Everyday	Warty	(1) 213 Warty 68 non-warty
	Vickery × Princess	Warty	———
Thick, tough skin & thin, tender skin	Vickery × Everyday	Thick, tough	(1) 213 thick, tough 68 thin, tender. also (2) 45 thick, tough 10 thin, tender.
Black spine and white spine	Vickery × Everyday	Black	(1) 211 black 70 white also (2) 42 black 13 white
	Princess × China	Black	———
	Vickery × Princess	"	———
	Early Russian × China	"	———

Note.—The characters in this group all show dominance and recessiveness with the typical 3:1 Medelian ratio in those that were carried to the F_2 generation.

1. Plants grown outdoors.
2. Plants grown under glass.

TABLE 2.

Characters	Parents Crossed	F1	F2
Dark bluish-green & white fruit	Vickery × Crystal White	Not like either parent but paler green than Vickery	(1) 25 dark bluish-green 160 intermediates 52 white
Dark bluish green & yellowish green fruit	Vickery × Everyday	Intermediate	(1) 222 plants grown fruits of various shades of green from dark to light.
White flesh and green flesh	Vickery × Everyday	Intermediate	(1) 62 white 181 intermediate 24 green.
Many spines and spineless	Vickery × Everyday	Intermediate	(1) 68 Spineless 213 spiny in various degrees from intermediate to many. (2) 12 spineless 29 intermediate 14 many.

NOTE.—It was practically impossible to classify accurately the F_2 generation in these cases but it is quite probable that more of the intermediates could have been put into one of the parental groups, e.g. some of the 160 in the intermediate colour group could perhaps have been put into the dark bluish-green group.

The intermediateness in the F_1 generation of each cross, together with what appear to be I : 2 : I ratios in the F_2 generations points to lack of dominance with one pair of factors only for each character in this group.

1. Plants grown outdoors.
2. Plants grown under glass.

Fruit shape: The shape of the fruit appears to be definitely connected with size factors, and also with factors for shape of certain of the parts of the fruit, but these have not been definitely determined. In some varieties the fruits are rather long and slender with a decided 'neck' (Everyday and China) while in others they are shorter and thicker with rounded ends and no neck (Vickery, Princess, and Early Russian). Others again are somewhat intermediate not only in total length and diameter, but also in the relation of different parts to one another. The main features in connection with shape, however, appear to be determined by the relationship between length and diameter, while other shape characteristics would seem to depend for their expression, in part at least, on the relative sizes of the various parts concerned. Two rather distinct types for shape (Vickery, short and thick with short round neck and no 'tip' at blossom end, and Everyday, long and slender with a somewhat pronounced 'neck' and 'tip') were used in one cross. Fruits of the F_1 plants of this cross were different from either parent, although there were some resemblances to both. The line drawings in Figure 5, I, II and III illustrate these differences in shape. This cross was carried to the F_2 generation, 55 plants being grown indoors and 285 outdoors, and various types of fruit were obtained. Some were like the parents, i.e. 'long and slender' (Everyday Pl. I, 3) and 'short and thick' (Vickery Pl. I, 1); others were like one parent in length and the other in diameter and vice versa so that in addition to 'long slenders' (Pl. II, 10) and 'short thicks' (Pl. II, 12) there were 'long thicks' (Pl. I, 6, 8, and Pl. II, 15) and 'short slenders' (Pl. I, 9) and various intergrading combinations of sizes and shapes.

TABLE 3.

Characters	Parents Crossed	F1	F2
Large & small leaves	Vickery × Everyday	Intermediate	(1) 26 large 257 intermediate 2 small Difficult to classify No measurements.
" " "	Everyday × Early Russian	"	
Dark green and pale green leaves	Crystal White × Vickery	"	(1) 220 plants of various shades of green, not distinct enough to classify.
Long and short internodes	Everyday × Princess	"	
Long and short fruit-stalks*	Vickery × Everyday	"	(2) 55 plants with various lengths, long to short.
Long and short fruits**	Early Russian × China	"	
" " " "	Early Russian × Everyday	"	
" " " "	Everyday × Princess	"	
" " " "	Princess × China	"	
" " " "	Vickery × Everyday	"	(2) 55 plants with various lengths, long to short.
Large and small spines	" "	"	(1) 11 large 250 intermediate 20 small

* Fruit-stalk lengths of parent varieties and of F1 and F2 generations are indicated in Fig. 3.

** Fruit lengths of parent varieties and of F1 and F2 generations of each cross together with the F2 of the Vickery × Everyday cross are indicated in Fig. 4.

NOTE.—The intermediateness in the F1 generation of each cross in this group of characters indicates that dominance is lacking and the F2 distribution of three of the character pairs points somewhat to the action of multiple factors.

1. Plants grown outdoors.
2. Plants grown under glass.

TABLE 4.

Characters	Parents Crossed	F1	F2
Non-clustering and clustering fruiting habit.	Crystal White × Vickery	(a) Non-clustering	
	Princess × China	(a) "	
	Vickery × Princess	(b) "	
	Everyday × Princess	(b) "	
	Early Russian × Everyday	(b) "	
	Vickery × Everyday	(b) "	45 almost non-clustering 7 somewhat clustered. 3 decidedly clustered. grown under glass.

a. Non-clustering is as marked in the F1 of these first two crosses as in the non-clustering parents Crystal White and China.

b. Non-clustering is not as marked in the F1 of these four latter crosses as in the first two.

It was very difficult to classify the F2 plants in the Vickery × Everyday cross, probably because the parents were not of the extreme type for this character. The cross Princess (extreme clustering) × China (non-clustering) would most likely have given a more clear-cut segregation.

It probably is not advisable to draw any conclusions from the data at hand although non-clustering would appear to have some degree of dominance.

In the same F_2 population the relationship of neck shape to the length of the rest of the fruit is rather interesting. It might be expected that the long, narrow, tapering neck of Everyday (Pl. I, 3) would always be associated with the long slender fruit of that variety, and the somewhat round, less tapering neck found always with the shorter, thicker fruit typical of Vickery (Pl. I, 1, and Figure 5). Instead fruits were found with rather long somewhat tapered necks and short bodies (Pl. II, 12) and with short, much less tapered necks and long bodies (Pl. I, 8 and Pl. II, 17 and 20). Furthermore, various intergrading combinations of neck and body shape were observed. This

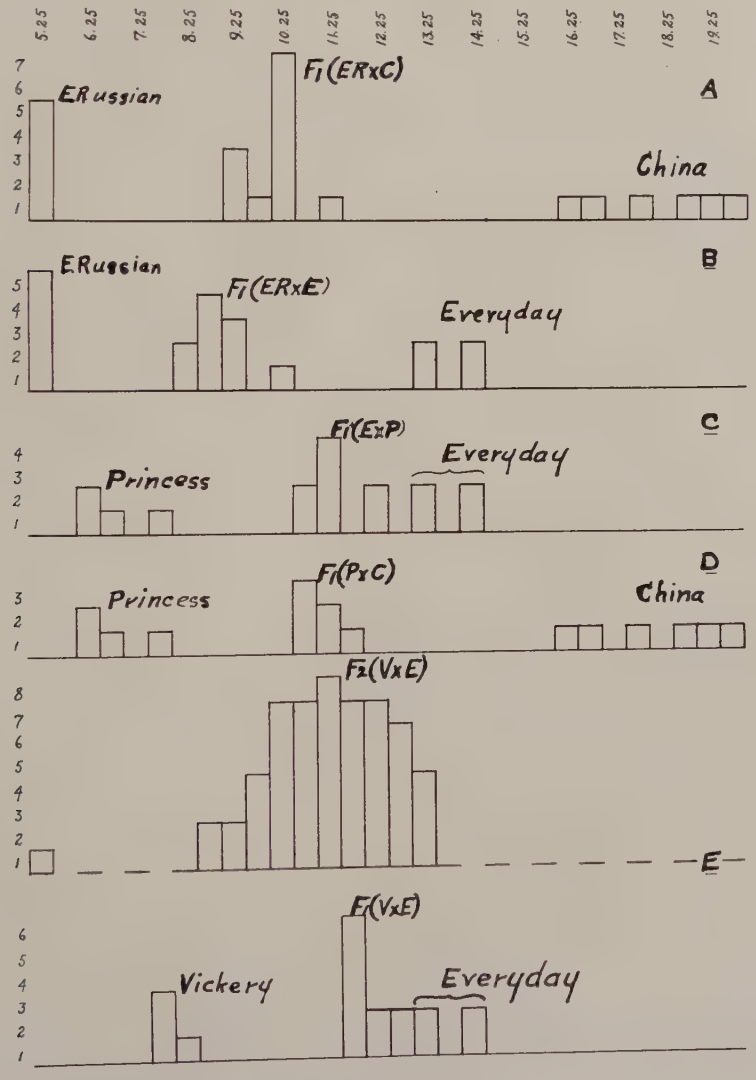

Figure 4. Diagrams illustrating fruit length in five crosses: A. B. C. D. carried to the F_1 generation, E to the F_2. A. Early Russian by China, B. Early Russian by Everyday, C. Everyday by Princess, D. Princess by China, and E. Vickery by Everyday. Numbers of plants at the side, length in inches above.

seems to be a case similar to the inheritance of shape in peppers in which two extreme types, i.e. 'long and narrow' and 'short and thick' were crossed, giving intermediate shapes in the F_1 and various intergrades of shape in the F_2 (Castle 1924).

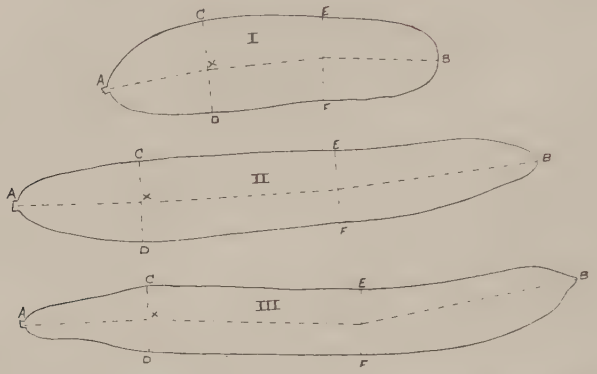

Figure 5. Drawings illustrating the shape of fruit in a cross between Vickery (I) and Everyday (III) and the hybrid (II).

Shape of blossom end is fairly distinct as will be seen from the diagrams (Figure 5, I, II and III) and from Plates I and II. The variety Everyday has a decided 'tip' while Vickery is 'round'. In a cross between these two varieties the fruits of the F_1 generation were all 'tipped' but the tip was somewhat modified in that it was considerably larger and not as pointed as in the Everyday parent. The same result was obtained when Everyday was crossed with Early Russian, the latter variety having rounded ends like Vickery. The F_2 generation of the first cross contained many fruits that were somewhat 'tipped' but the shape of the tip was not always the same. In some it was almost the same shape as in the F_1 generation, in others it was more like the Everyday parent, in a few it was 'round' like the Vickery parent, while in still others it showed intergradations between these three types.

The fact that all the F_1 generation were 'tipped' although modified, suggests that 'tip' may be partially dominant to 'round', and that a modifying factor causes the expression of 'tip' in this generation to be somewhat different from that in the 'tipped' parent.

It was difficult to classify the F_2 fruits of this character, but the majority, possibly three quarters, were tipped in various degrees and the rest not tipped.

There would seem to be room for a considerable amount of careful and detailed study before all the factors involved in fruit shape could be determined.

Linkage

Perhaps the most interesting thing observed in these experiments is the apparent linkage of several of the fruit characters. Thus 'mottled' 'dull', 'warty', 'thick' and 'tough' were always found together in the same fruits; likewise their allelomorphs 'non-mottled', 'glossy', 'non-warty', and 'thin' and 'tender'. The dominant members of these pairs of characters were found

associated together in the American White Spine type of cucumber while their recessive allelomorphs were found typically in the English forcing kinds. In crosses between these two types the writer found that all plants in the F_2 and F_3 generations bore fruits that were one type or the other as far as these characters were concerned. While linkage is offered as the explanation of this close association of these characters yet it must not be overlooked that each group of characters may be due to the action of a single factor.

Discussion

It is evident from this study that the cucumber, in common with other plants possesses characters of varying degrees of complexity as regards their inheritance. A few show simple dominance and recessiveness while the majority do not. These latter although not showing dominance and recessiveness appear, in a few cases, to be due to single factors while others are more complicated with several factors entering in the numbers, however, not being determined.

Theoretically, it is possible to produce cucumber plants with many recombinations of characters, but from the number of factors that appear to be involved and from the apparent close linkage of certain characters it is evident that enormous populations would have to be grown in order to obtain all that are most desirable.

Considering the complexity of the inheritance of the majority of characters in the cucumber plant it will readily be seen that the breeder of cucumbers, in common with other plant breeders, has no easy task, nevertheless a knowledge of the manner of inheritance of some of these characters should help toward more intelligent breeding practices which would be reflected in the production of new varieties that would be better adapted to the practical growers' needs.

Summary

1. Much hybridization work with the cucumber has been carried on but very little data on the inheritance of characters has been recorded.

2. This study was carried on for the purpose of obtaining data on the inheritance of a few of the more outstanding characters in the cucumber.

3. Seven characters showed complete dominance:—Regular length of internode dominant to irregular. Grooved and ridged stem dominant to smooth and round. Mottling of fruit dominant to non-mottling. Dullness of fruit dominant to glossiness. Wartiness of fruit dominant to non-warty. Thick tough skin dominant to thin tender. Black spines dominant to white.

4. Nine characters lacked dominance and of these three appeared to be inherited on a one factor basis giving approximately a 1:2:1 ratio:—

Colour of fruit
Colour of spines
Number of spines.

The other six were on a multiple factor basis:—

Size of leaves
Colour of leaves
Length of internodes
Length of fruit stalks.
Length of fruits.
Size of spines.

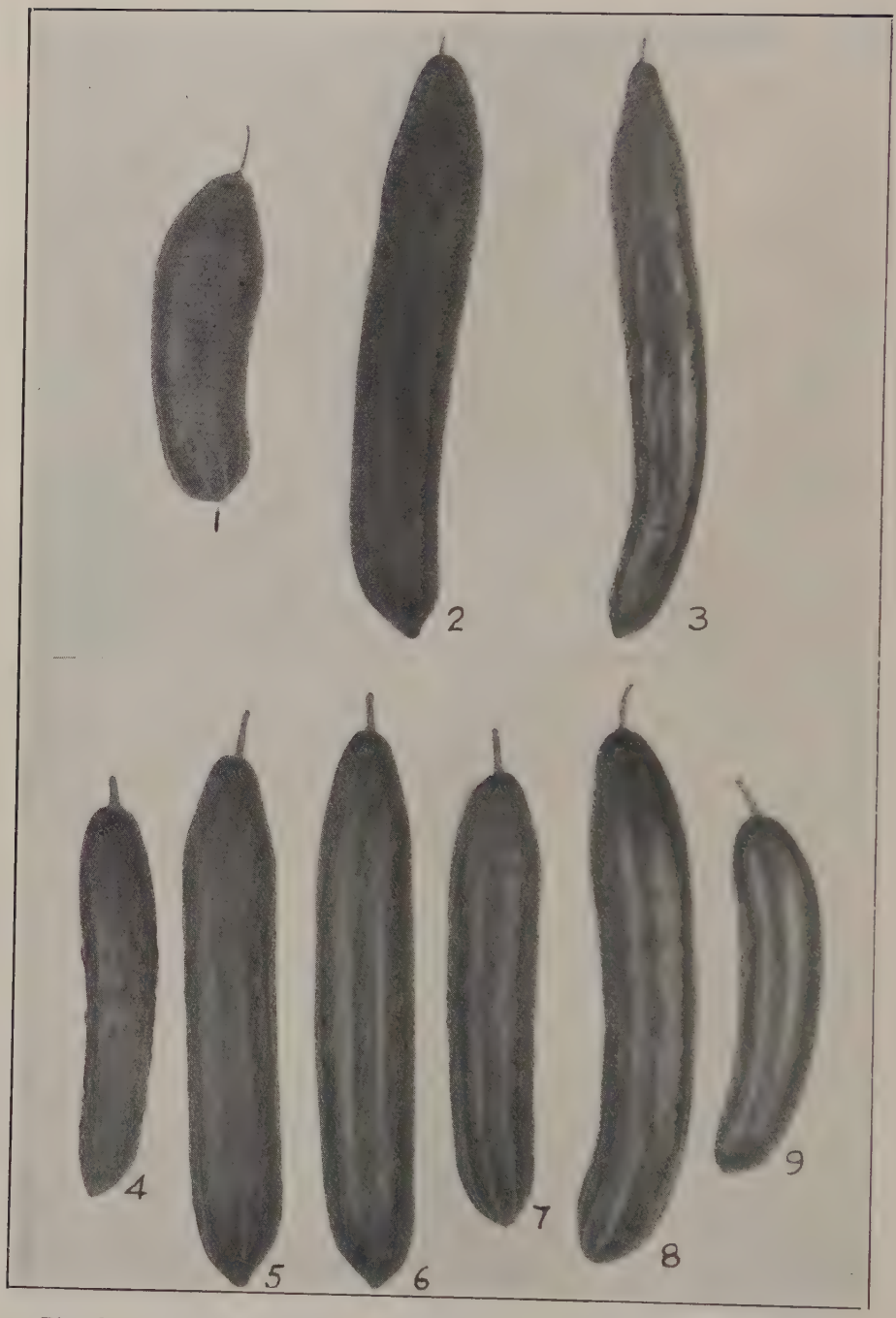

Plate I, 1. Vickery parent; 2, F_1 fruit of Vickery by Everyday; 3, Everyday parent; 4 to 9, F_2 fruits of Vickery by Everyday cross.

Plate II, 10 to 21. Other F_2 fruits of same cross.

5. The non-clustering fruiting habit appeared to be dominant to clustering, at least, in some cases and only partially dominant in others.

6. Shape of fruit appeared to be dependent on several size and shape factors but its mode of inheritance was not determined.

7. There appeared to be linkage between the fruit characters mottled, dull, warty, thick and tough, and non-mottled, glossy, non-warty, thin and tender.

Acknowledgments

This study was carried on under the supervision of the Department of Botany of the University of Toronto, and I am much indebted to Professor R. B. Thomson for his many helpful suggestions and criticisms given during the progress of the work. My thanks are due to Miss M. B. Givens of the Department of Botany, for assistance in preparing the figures and plates.

The breeding experiments were carried on at the Ontario Horticultural Experiment Station at Vineland, and I wish to express my thanks and appreciation to Mr. E. F. Palmer, Director of the Station, for providing facilities for carrying on these experiments, and to Mr. J. R. vanHaarlam, of the Station staff, for photographs of cucumber fruits.

I also wish to acknowledge sources of seed for this work, which were as follows: American types: J. C. Robinson Seed Company, Nebraska; J. B. Rice Seed Company, New York. English types: Sutton and Sons, England. French varieties: Vilmorin et Cie, France. Other types: one from Bangalore, India, by courtesy of Dr. L. C. Coleman, Director of Agriculture, Mysore, India; one from Ceylon, by courtesy of F. J. Chittenden, Director of the Royal Horticultural Society Gardens, Wisley, England; African Horn Cucumber from Brunning Seed Company, Melbourne, Australia.

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POWDERED SKIMMILK FOR WEANLING PIGS

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It has often been said that the feeder who has unlimited quantities of skimmilk or buttermilk has no real problem in so far as feed for his pigs is concerned. This, of course, is but another way of saying that these dairy by-products are what may be called "protective" foods, in that they are rich in some of those nutritional elements necessary for the proper growth of small pigs, which are lacking in most grains and their by-products.

Unfortunately, however, not every pig feeder has available either of these products. Nor does every dairy man have hogs. Most creameries, on the other hand, have a surplus of these products which until rather recently were often thrown away.

Today many concerns are salvaging these materials by converting them into less perishable forms such as semi-solid buttermilk or milk powders.

Skimmilk powder finds many uses in the human diet, but in its preparation there is always found a certain proportion of slightly discoloured or otherwise damaged material which while rejected for use for human food is in no way injured for animal feeding.

Its use for the latter purpose, however, has not been extensive, and mostly confined to calf rations. Little is known of its feeding value for weanling pigs. What studies have been reported suggest that on a dry matter basis it is equal to the liquid product for this class of stock.

Considering the high esteem in which the fluid product is held by pig feeders, it seemed entirely likely that the dried product might prove of considerable value when the former could not be obtained.

A trial was, therefore, carried out during the spring of 1930 to evaluate powdered skimmilk as a protein and mineral supplement for newly weaned pigs as compared to the standard protein-mineral supplementary mixture regularly in use at the Macdonald College Piggery.

Animals Used and Management During the Trial

The data herein reported involve two lots of 10 Yorkshire pigs each, fed for a period of 32 days immediately following weaning. The pigs were confined to and fed throughout the trial in individual pens. Allotment was made in pairs, one pig of each pair being put into each lot. The pairs were put on feed as they became available, and they ranged in age from 51 to 66 days at the start of their respective feeding periods.

No attempt was made to effect uniformity within the two lots, but pair mates were chosen as closely alike as possible. In all cases but one (pigs 9 and 9a) pair mates were littermates.

The exact details of the allotment are given in Table 1.

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TABLE 1.—*Powdered Skimmilk for Weanling Pigs.*

Feeding Periods			Lot 1. Tankage-Fishmeal-Oilmeal-Mineral Supplement							Lot 2. Powdered Skimmilk							
From	To	Days	Pig No.	Age	Initial Weight	Final Wt.	Gain	Feed Eaten	Gain per 100 lbs. feed eaten	Pig No.	Age	Initial Wt.	Final Wt.	Gain	Feed Eaten	Gain per 100 lbs. Feed eaten	Diff. in gain per 100 lbs. Feed Eaten
Apr. 17/30	May 19/30	32	1	51	28	Died	—	—	—	1a	51	26	removed	—	—	—	—
Apr. 17/30	May 19/30	32	2	51	29	70	41	109	38	2a	51	29	85	56	115	49	+ 11
Apr. 17/30	May 19/30	32	3	51	18	54	36	95	38	3a	51	22	66	44	96	46	+ 8
Apr. 17/30	May 19/30	32	4	66	34	87	53	134	40	4a	66	34	82	48	104	46	+ 6
Apr. 17/30	May 19/30	32	5	66	38	85	47	118	40	5a	66	40	101	61	138	44	+ 4
Apr. 17/30	May 19/30	32	6	66	34	79	45	122	37	6a	66	27	74	47	105	45	+ 8
May 19/30	June 20/30	32	7	60	36	89	53	113	47	7a	60	38	82	44	89	49	+ 2
May 19/30	June 20/30	32	8	60	28	76	48	77	62	8a	60	26	66	40	73	55	- 7
May 19/30	June 20/30	32	9	60	33	82	49	109	45	9a	59	34	74	40	83	48	+ 3
June 4/30	July 6/30	32	10	59	22	62	40	76	53	10a	59	22	65	43	75	57	+ 4
June 4/30	July 6/30	32	11	59	19	62	43	80	54	11a	59	19	66	47	77	61	+ 7

Mean difference in gain per 100 lbs. feed eaten in favor of Lot 2.....4.6 lbs.
Standard deviation of differences.....4.66
Z value to give odds of 30 to 1—10 pairs.....71
Necessary difference between gains to cover uncontrolled variation (4.66 x .71).....3.31 lbs.
Net difference in favor of Lot 2 creditable to differences in feed.....1.3 lbs.

Rations Fed

Animals in Lot 1 were fed the following meal mixture:

Ground Corn	350 lbs.
Wheat Middlings	350 lbs.
Protein-Mineral Supplementary Mixture	300 lbs.

The Protein-Mineral Supplementary Mixture is one prepared by the author for general use at Macdonald College piggery. It consists of:

400 lbs.	High Grade Tankage.
200 "	Linseed Oilmeal
200 "	Fish Meal
100 "	Bone Meal
76 "	Ground Limestone
20 "	Salt
4 "	Ferric Oxide

Pigs in Lot II were fed the same basal mixture of Ground Corn and Middlings but with the 300 lbs. of Protein-Mineral Supplement replaced by an equal quantity of Powdered Skimmilk.

Feeding was done three times per day. The dry meal was measured into each trough at each feed and the water allowance poured over it. All pigs were full hand fed throughout the trial.

The Data

In Table 1 are found the complete data relative to this trial. A summary of these data appears in Table 2.

Table 2.—*Summary of Data. Powdered Skimmilk for Weanling Pigs.*

	LOT 1. Tankage-Fishmeal Oilmeal-Mineral Mixture	LOT II. Powdered Skimmilk
No. of Pigs	10	10
Days on Feed	32	32
Average Initial Weight	29.1 lbs.	29.1 lbs.
Average Gain 32 days	45.5 "	49.2 "
Average daily gain	1.42 "	1.54 "
Average feed eaten in 32 days	103.3 "	95.5 "
Average gain per 100 lbs. feed eaten	45.4 "	50.0 "
Average difference in gain per 100 lbs. feed eaten		4.6 "
Necessary difference to cover uncontrolled variability		3.3 "
Net difference creditable to differences in feed		1.3 "

Discussion of Results

While the results of this trial are based on ten pairs of pigs, it will be noted in Table 1 that eleven pairs were started on feed. Pig No. 1 was found dead in his pen on May 19th after having been sick for three days. No post mortem examination was made on this pig and no reason for its death determined. His pair mate No. 1a was removed from the trial and the performance of this pair deleted from the data in analysis.

The method of analysis used is a modification of "Students Method" proposed by the author (*1*) in which the results are based upon differences observed between pairs rather than between groups.

Between the ten pairs there was an average difference in favor of the Powdered Skimmilk (Lot II) of 4.8 lbs. of gain per 100 lbs. of air dry feed eaten. Of this, 3.3 lbs. must be allowed (odds of 30 to 1) for uncontrolled variability.

This leaves a net difference in favor of Lot II of 1.5 lbs. of gain for each 100 lbs. of feed eaten, or expressed differently, we find that the Skimmilk Powder Mixture produced approximately 2.9% greater gains than the ration of the check lot.

It might be mentioned that the progress of both lots was noteworthy. Live weight gains of 1.42 lbs. and 1.54 lbs. per pig per day are considerably above the average for pigs of this age. It may be of interest that these gains are quite in line with those which have been realized regularly at Macdonald College Piggery with pigs carried on the ration of Lot I of this trial.

As a possible explanation of this exceptional progress attention is directed to the protein levels of the rations. That of the check lot is approximately 20% (digestible) and that of Lot II slightly less. These protein levels may be considered unnecessarily high by some, largely because of the cost of such mixtures, but when it is remembered that the ration these youngsters were accustomed to before they started to eat "man made" meals, carried some 40% of protein, it is not hard to believe that too great a change in the ration just when they are at the most critical time in their race to the butcher, is not the best practice.

While there are not at present sufficient data to prove the case, there is considerable evidence to support the view that within certain limits rate of gain in young animals is very closely correlated with their protein intake.

Experiences at Macdonald College lead us to the conclusion that in raising market pigs the use of rations somewhat higher in protein than are ordinarily fed are economical and to be strongly recommended. Gains are actually produced at a cheaper cost per pound even though the rations are more expensive per ton.

Summary

1. A basal mixture of Corn and Middlings supplemented by 30% of Powdered Skimmilk (Lot II) produced average daily gains on weanling pigs of 1.54 lbs. per pig as compared to a similar basal mixture supplemented by 30% of a Tankage-Fish Meal-Oilmeal-Mineral combination (Lot I) with which average daily gains of 1.42 lbs. were obtained.
2. An average "net difference" in favor of the Powdered Milk (Lot II) of 1.3 lbs. gain per 100 lbs. of feed eaten was realized.
3. As fed in this trial, the Powdered Skimmilk Mixture was 2.9% more efficient in producing gains on pigs for the first month after weaning than was the check ration.

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YEAST INFECTION OF NORMAL HONEY AND ITS RELATION TO FERMENTATION*

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[Received for publication January 12, 1931]

Introduction

From the results of a number of investigations (*1, 3, 4, 5, 6*), fermentation of honey is now generally recognized to be due to the action of sugar-tolerant yeasts, capable of developing in concentrated sugar solutions which are able to suppress "ordinary" non-osmophilic yeasts such as *S. cerevisiae, S. ellipsoideus,* etc. The sources of infection of honey by such yeasts appear to be varied. In a study of flowers commonly visited by bees during the honey flow, Lochhead and Heron (*3*) isolated 11 different yeasts capable of fermenting high concentrations of honey, while concurrent studies of nectar from hives throughout the season yielded results indicating an early and constant infection by sugar-tolerant yeasts. This infection is probably unavoidable, even though doubtless greatly variable, representing infection carried by the bee along with floral nectar, which assumption is supported by the findings of Wilson and Marvin (*7*) who report the isolation of yeasts from the bodies of bees and likewise from pollen stored within the hive.

In studying soil as a source of infection, Lochhead and Farrell (*2*) found soil from apiary ground to be regularly infected by sugar-tolerant yeasts, while ordinary field soil was found to be free from such organisms. These authors suggest that although apiary soil serves probably as a resting place for honey-fermenting yeasts, presenting no favourable opportunity for growth or multiplication, yet it may constitute a source for seasonal reinfection through such agencies as wind, insects, etc. That yeast infection, however, is partly within the control of the beekeeper is indicated by further studies of the first-named authors (*3*) who isolated honey-fermenting yeasts from honey tanks, containers and air of the honey-extracting house, so that the exercise of strictly sanitary precautions at the time of extraction is recommended as a partial means of control of yeast infection.

In the light of the experimental work referred to, the probability of all honey being infected with sugar-tolerant yeasts, at least in some degree, appears very great. Nussbaumer (*5*) found evidence of yeasts in 34 out of 38 samples of Swiss honeys and in 18 out of 23 foreign samples examined, while Marvin (*4*) expresses the belief that yeast cells are found in almost all honeys.

No data are available, however, as far as we are aware, relating to the amount of yeast infection present in normal honey, and consequently the

*Contribution from the Division of Bacteriology, Dominion Experimental Farms, Ottawa. The authors wish to acknowledge with thanks the co-operation of the Dominion Chemist in connection with the chemical analyses referred to, representing the work of Dr. C. J. Watson and Miss D. Heron of the Division of Chemistry. The authors are also indebted to the Dominion Apiarist and to Mr. W. G. LeMaistre for securing and classifying the samples of honey examined.

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investigation here reported had for its object the determination of the extent to which honey from different localities and of various floral sources is contaminated with sugar-tolerant yeasts. Furthermore, it was hoped to obtain information on the question as to whether the amount of yeast infection, as distinct from the mere presence of yeast, is a factor in causing fermentation.

Experimental

Through the agency of the Bee Division, 211 samples of honey from the 1929 crop were obtained from all parts of Canada. Of these, 18 samples were received from different Experimental Farms, the remainder being furnished by private beekeepers. In almost all cases duplicate samples of the same run were submitted, in 5 lb. or 2½ lb. tins, in 2 lb. glass jars or, very rarely, in 1 lb. jars. In the few cases where duplicates were not obtained, the sample was immediately divided, using sterile jars. One sample of each lot was kept for storage at ordinary room temperature for the determination of keeping quality (Bee Division), the other sample being used for analysis (Bacteriological and Chemical Divisions). It was found that of the 211 samples, 20 had been subjected to some degree of heating; hence these were not considered in the present work, so that the data here presented refer to determinations made on 191 samples of normal Canadian honey.

The estimation of the amount of yeast infection was made by the dilution method. From every sample of honey, tubes were prepared containing respectively 10.0, 1.0, 0.1, 0.01, 0.001, 0.0001 and 0.00001 gram of honey. In order to provide conditions favorable to fermentation, cultures were so prepared that each tube contained a medium consisting of 2 parts by weight of honey diluted by the addition of 1 part of a nutrient solution of the following composition:

Peptone	1.0 gram per liter
K_2HPO_4	1.0 " " "
$MgSO_4$	0.5 " " "
Amm. tartrate	0.5 " " "
NaCl	0.1 " " "
$CaCl_2$	0.1 " " "

For the 10-gram sample the honey was weighed out directly into a large test-tube to which was added 5 c.c. of the nutrient solution, while for all other samples the appropriate amount was measured into flasks containing 10 c.c. of the honey-nutrient medium described. In preparing dilutions of honey for quantitative work it had previously (*3*) been found advisable, for obtaining maximum counts, to employ sterile honey solution for dilution blanks instead of water; consequently in preparing the dilutions indicated, sterile blanks of 50 per cent honey solution were used.

All cultures were prepared in duplicate, incubated at room temperature and examined weekly for the presence or absence of fermentation, tubes being held, if necessary, for 6 weeks before finally recording negative results. Fermentation was found to be due to the action of yeasts. This finding was confirmed in the course of a concurrent study of the types of yeast occurring in greatest numbers in normal honey and which will be reported elsewhere. In this special investigation tubes showing fermentation with the highest dilution of honey were plated out and yeasts isolated in all cases.

The samples held in storage were examined periodically by the staff of the Bee Division and records kept of all samples which showed evidence of spoilage by fermentation.

Results and Discussion

From table 1, giving a summary of the results of yeast counts by the dilution method, it is seen that in no case was a sample found to be free from sugar-tolerant yeasts. Considerable variation, however, was noted in the amount of yeast infection, ranging as it did from 1 in 10 gram to over 100,000 per gram of honey, with a median count of 1,000 per gram.

Table 1.—*Summary of yeast counts of 191 samples of normal honey.*

Yeast Count	No. of Samples
1 in 10 gram	3
1 in 2 "	2
1 per gram	6
5 " "	9
10 " "	7
50 " "	15
100 " "	28
500 " "	24
1,000 " "	33
5,000 " "	27
10,000 " "	24
50,000 " "	9
100,000 " " or more	4

The relationship of yeast count to fermentation is shown in table 2, in which are recorded, for different yeast count groups, samples which, at the end of a period of storage of 14 months at room temperature, were found to show evidence of fermentation. The relationship is also indicated in figures 1 and 2.

Table 2.—*Relation of yeast count of honey to fermentation within 14 months.*

Yeast count per gram	Total No. of samples	Fermented		Unfermented		% in group fermenting
		Total	Percentage distribution	Total	Percentage distribution	
Less than 1	5	0	0.0	5	3.3	0.0
1-10	22	3	7.5	19	12.6	13.6
11-100	43	5	12.5	38	25.2	11.7
101-1,000	57	10	25.0	47	31.1	17.6
1,001-10,000	51	15	37.5	36	23.8	29.4
over 10,000	13	7	17.5	6	4.0	53.9
Total	191	40	100.0	151	100.0	Aver. 20.9

It will be observed that the higher the initial yeast count of honey the greater is the probability of its fermenting. No definite line can be drawn, however, between honeys which will ferment and those which will not on the basis of yeast count, nor are we justified in deducing from the above data that a high yeast count is the cause of fermentation. A determination of the yeast content, however, serves as some measure of the fermenting tendency of honey.

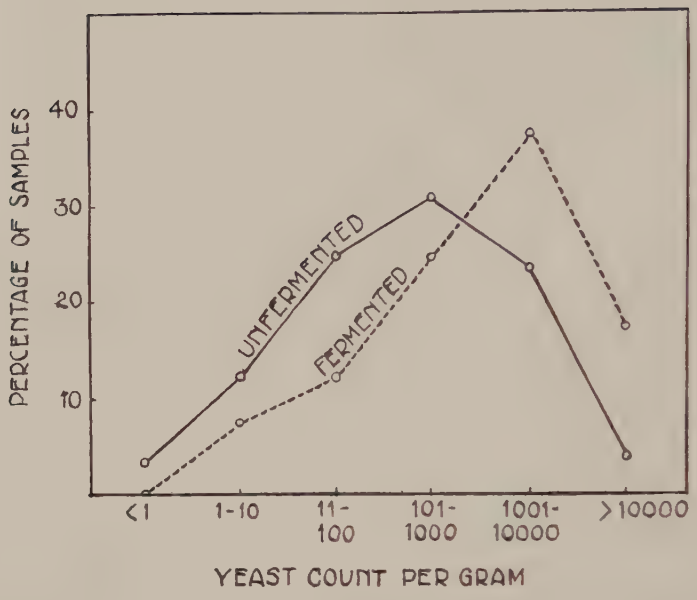

Figure 1. Percentage distribution, according to original yeast count, of fermented and unfermented honeys (14 months' storage at room temperature.)

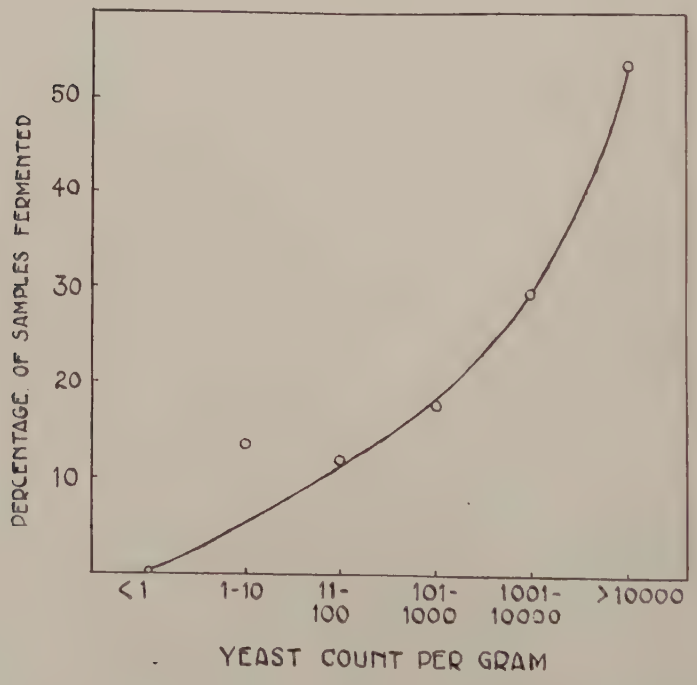

Figure 2. Yeast count of honey in relation to fermentation after 14 months' storage.

Yeast Count and Chemical Composition of Honey

In addition to being examined for yeast content, the samples of honey were submitted to chemical analysis by the Division of Chemistry and determinations consequently made of moisture, invert sugar, sucrose, levulose, dextrose, total ash, total nitrogen, titratable acidity and hydrogenion concentration. The results of the chemical analyses will be presented in detail elsewhere, so that the present paper concerns itself only with a comparison of the analytical figures as they relate to the yeast count.

In table 3 is presented a summary showing the average chemical composition of the honey samples arranged in groups according to the yeast count. It will be observed that one relationship only appears to stand out prominently, namely that between yeast count and moisture content* (see also figure 3), the amount of yeast infection tending to rise with increasing moisture. Whether the yeast count is merely a function of the moisture content, or whether it stands in casual relationship to fermentation is a matter to be further considered.

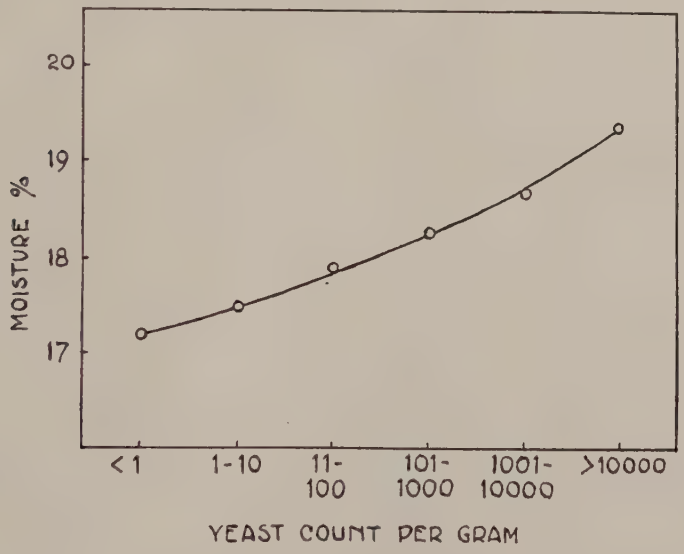

Figure 3. Yeast count of honey in relation to moisture.

The data in table 3 refer to the honeys as a whole, quite irrespective of whether they showed fermentation or not within 14 months. Within any one yeast count group, however, variation in the chemical composition was seen. Accordingly, to note whether the composition stands in relation to fermentation, the data were recalculated to distinguish between honeys which fermented, and those which remained unfermented within 14 months. This summary is presented in table 4, from which it will be observed that of the chemical factors which appears to be related to fermentation, moisture is the most important, with such factors as ash content, nitrogen content, titratable acidity and sucrose content being probably related though in a much lesser degree.

*Moisture was determined by the refractometer method.

TABLE 3.—*Relation of yeast count to chemical composition of honey.*

Yeast count	Total No. of Samples	No. of samples analysed chemically	Moisture	Invert sugar	Sucrose	Levulose	Dextrose	Lev. / dex.	Ash	N	Acidity	pH
Less than 1	5	5	17.2	74.9	3.2	40.6	36.2	1.12	0.071	0.057	19.8	3.7
1 - 10	22	20	17.5	76.4	1.8	42.1	35.7	1.18	0.076	0.049	17.1	3.7
11 - 100	43	41	17.9	75.7	1.6	41.2	35.7	1.16	0.073	0.042	17.4	3.9
101 - 1,000	57	53	18.3	75.3	1.9	41.5	35.2	1.18	0.071	0.034	15.8	3.9
1,001 - 10,000	51	50	18.7	75.0	1.8	41.4	35.2	1.18	0.058	0.033	16.8	3.8
Over 10,000	13	12	19.4	74.1	1.9	41.0	34.6	1.19	0.074	0.049	18.4	3.8

TABLE 4.—*Chemical composition in relation to fermentation of honeys of various yeast content.*

Yeast count		Moisture	Invert Sugar	Sucrose	Levulose	Dextrose	Lev. / dex.	Ash	N	Acidity	pH
Less than 1	Fermented	..	..	..	..	..	..	..	..	..	..
	Unfermented	17.2	74.9	3.2	40.6	36.2	1.12	0.071	0.057	19.8	3.7
1 - 10	Fermented	19.7	75.0	0.5	40.1	36.5	1.10	0.150	0.137	30.7	4.0
	Unfermented	17.1	76.6	2.0	42.5	35.6	1.19	0.063	0.033	14.7	3.6
11 - 100	Fermented	19.1	75.9	0.9	40.8	36.5	1.12	0.074	0.058	20.3	3.9
	Unfermented	17.8	75.7	1.7	41.2	35.6	1.16	0.073	0.040	17.1	3.9
101 - 1,000	Fermented	19.6	74.3	1.8	40.9	34.9	1.17	0.063	0.035	17.5	3.8
	Unfermented	18.0	75.5	1.9	41.6	35.3	1.18	0.073	0.034	15.5	3.9
1,001 - 10,000	Fermented	19.2	75.1	1.1	41.7	35.1	1.19	0.058	0.034	16.7	3.7
	Unfermented	18.5	75.0	2.1	41.3	35.2	1.17	0.058	0.033	16.8	3.8
More than 10,000	Fermented	20.3	73.9	1.1	41.4	34.0	1.22	0.102	0.066	21.5	3.8
	Unfermented	18.6	74.3	2.6	41.0	35.1	1.17	0.045	0.033	15.3	3.8

With moisture as the outstanding chemical factor, the data were recalculated to eliminate this influence by arranging the honeys in groups according to moisture content. From table 5, in which are summarized the average and median yeast counts of fermented and unfermented samples respectively, it will be observed that the fermented samples tended to reveal a higher original contamination than unfermented samples, exclusive of moisture content. From the data there is evidence to support the view that the yeast count of honey is a factor directly affecting fermentation, and is not simply a function of the moisture content. The distribution of fermented and unfermented samples with respect to their moisture content and yeast infection is shown in figure 4.

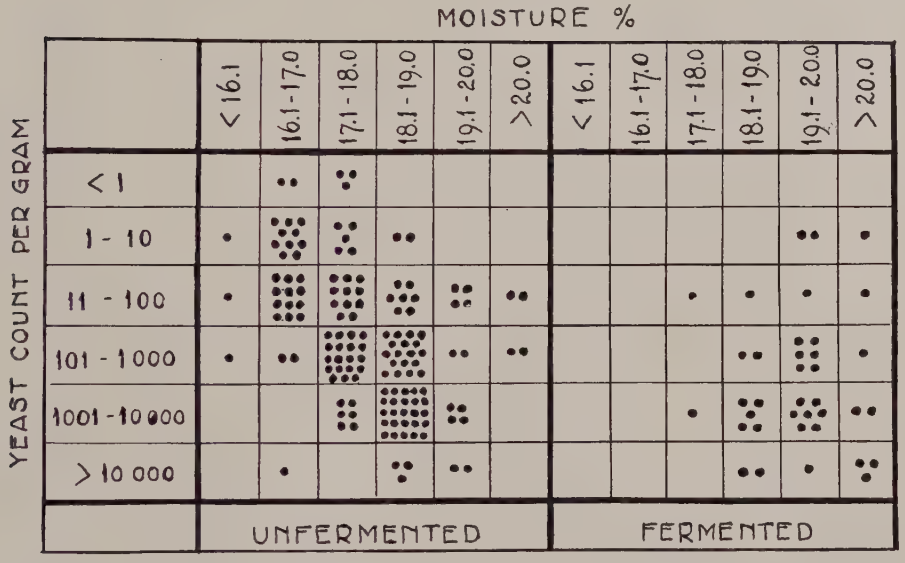

Figure 4. Distribution of fermented and unfermented samples with respect to yeast count and moisture.

Floral Origin

In the case of 176 samples out of 191, information was obtained as to the floral origin of the honeys and in table 6 are summarized the data according to three groups into which the samples were divided on the basis of the type of nectar contributing to their composition. The samples containing buckwheat showed a higher average, but a lower median, yeast count than those of the other groups, due to a higher percentage of counts in both the low count and high count ranges, indicating that in this group of honeys greater variation in yeast count was observed. As was to be expected in view of the practical observations of honey producers, samples containing buckwheat showed a higher percentage of fermented samples, than the other groups revealing, at the same time, a higher average moisture content.

TABLE 5.—*Yeast infection in relation to fermentation of honeys of different moisture content.*

Moisture %		No. of samples	Yeast count	
			Average	Median
Less than 16.1	Fermented	0	..	..
	Unfermented	3	350	50
16.1 - 16.5	Fermented	0	..	..
	Unfermented	8	90	30
16.6 - 17.0	Fermented	0	..	..
	Unfermented	19	2,700	50
17.1 - 17.5	Fermented	0	..	..
	Unfermented	13	1,290	500
17.6 - 18.0	Fermented	2	5,050	5,050
	Unfermented	31	1,410	500
18.1 - 18.5	Fermented	3	5,340	5,000
	Unfermented	36	4,490	1,000
18.6 - 19.0	Fermented	7	32,350	10,000
	Unfermented	19	9,690	5,000
19.1 - 19.5	Fermented	14	9,940	750
	Unfermented	9	8,430	500
19.6 - 20.0	Fermented	3	5,340	5,000
	Unfermented	3	18,670	5,000
More than 20.0	Fermented	8	26,960	7,500
	Unfermented	4	430	300

GEOGRAPHICAL DISTRIBUTION

To note whether the yeast infection of honey varied according to the geographical origin, the samples were divided into five groups according to the areas in which they were produced. In table 7 is presented a summary showing the average and median yeast counts and the average moisture content of honeys from different portions of Canada. In view of the possibility that differences in honey from widely distant areas might be ascribed to differences in their floral origin, the table contains, in addition to data referring to the samples as a whole, a summary relating to honeys of one floral origin, namely clover. It will be observed that whether the honeys as a whole are considered, or only those of one floral origin, there are noticeable differences in the amount of yeast infection, which is seen to be distinctly greater in honeys from the Eastern Provinces than in those from the West. The honeys from British Columbia and the Prairie Provinces are likewise characterized by a generally lower moisture content, so that with a combination of favourable factors, honeys from the western part of Canada reveal a distinctly lower percentage of cases of fermentation than honeys produced in the eastern part of the Dominion. Just to what extent the lesser yeast infection of western honeys is to be ascribed to lower moisture, less contaminated nectar, soil etc., or more careful handling is not yet possible to determine.

TABLE 6.—*Floral origin in relation to yeast count and moisture content of honey.*

Floral origin	No.	Yeast count		% Distribution of yeast count				Moisture	Fermented	
		Average	Median	not more than 100	101-1,000	1,001-10,000	more than 10,000	%	No.	%
Clovers, including alfalfa	82	5,350	1,000	23.2	28.0	43.9	4.9	18.2	17	20.7
Clover and other flowers except buckwheat	78	4,450	500	47.4	33.3	14.1	5.3	18.1	11	14.1
Buckwheat alone or with other flowers	16	18,940	100	56.2	18.8	0	25.0	19.1	8	50.0

TABLE 7.—*Geographical distribution in relation to yeast count and moisture content of Canadian honeys.*

Location	No. of Samples	Yeast count				Moisture %		Fermented	
		All samples		Clovers		All samples	Clovers	No.	%
		Average	Median	Average	Median				
British Columbia	18	1,010	100	200	100	17.2	17.5	1	5.6
Prairie Provinces	64	1,710	100	1,320	100	17.9	17.6	8	12.5
Ontario	57	7,850	1,000	5,610	5,000	18.4	18.3	15	26.3
Quebec	43	11,950	5,000	15,390	5,000	19.2	19.0	13	30.2
Maritime Provinces	9	20,330	10,000	10,000	10,000	18.3	18.2	3	33.3

Summary

An examination of 191 samples of normal Canadian honey showed the presence of sugar-tolerant yeasts in all cases, though the amount of infection, as revealed by yeast counts by the dilution method, showed wide variation, with a median count of 1,000 per gram.

The tendency of honey to ferment was found to increase with increasing yeast infection. Although the yeast count tended to increase with increasing moisture content, yet it is not regarded as simply a function of the latter. Data presented support the view that the amount of yeast infection is a factor directly affecting fermentation.

No outstanding differences were found in yeast infection of honeys with respect to their floral origin. Honeys containing buckwheat nectar showed a notably higher moisture content than those of other floral origin and a greater tendency to ferment.

Honeys from the Western Provinces of Canada, in addition to showing a lower average moisture content, revealed a lower yeast infection than those from the Eastern Provinces. A progressively increasing yeast count was found from West to East which corresponded with the tendency to ferment.

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SOILS AND SOIL TREATMENTS IN QUEBEC

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In the settled agricultural parts of Canada, east and west, the general farmer is beginning to ask himself the question: 'Shall I make use of chemical fertilizers and to what extent shall I do so?' In our country, in such specialized farming propositions as apple growing, potato growing, tobacco growing, and general truck farming, chemical fertilizers have long been used on the land by experienced growers, with excellent results in better quality and increased quantity of crop.

In countries like the British Isles, the east central and southeastern United States, and in Germany, good general farming practice involves the use of lime and of chemical fertilizers. The great majority of the general farmers, dairy farmers and beef growers in Canada have not made much, if any, use of chemical fertilizers or of lime. The importance of the question is being brought home to them today by the agricultural press, by the publication of experimental findings, and by the establishment of such great plants for the manufacture of chemical fertilizers as those of Consolidated Smelters at Trail, British Columbia, and of Canadian Industries Limited, at Beloeil, Quebec. Evidently a great increase in sales of chemical fertilizers to farmers may be expected to result from the establishment of these huge industrial plants, and if farmers are to benefit as they should from lower prices for fertilizing materials, all possible sources of unbiased information must be made accessible to them.

Commonly, chemical fertilizers are considered from the standpoint of crops, with but little attention paid to underlying soil conditions. Each of the crops mentioned in the first paragraph is best adapted to quite definite soil types. Expressions recognizing these soil types are in common practical use: 'Orchard soils', 'tobacco soils', 'potato soils', 'truck garden soils' refer to soils in most cases of clear-cut chemical and physical nature, differing widely from each other. It is only through the soil that crops can make any use of applied chemical fertilizers, but in too many instances this fundamental fact is relegated to the background. In this connection the words of one of the leaders in present-day plant nutrition studies, Hoagland, (*2*) may be quoted:—

"The point of interest, as far as crop growth is concerned, is the resultant condition of the soil after fertilizers or other amendments are added. The same fertilizer will produce different effects, in greater or less degree, in every different soil. Sometimes reference is made to the use of 'balanced fertilizers'. *The balance which is important is not in the fertilizers, but in the soil after the fertilizer has been added and has reacted with the soil* † A fertilizer cannot, in any accurate sense, be compared with a 'balanced

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†The italics are the present writers.

ration' for an animal. The feeding of animals and the absorbing of mineral elements by plants are totally different in nature."

In the State of Maryland, which uses an enormous amount of chemical fertilizers in proportion to its area, there are recognized many distinct kinds or 'series' of silt loam soils. It is well known to Maryland farmers that the same application of fertilizer to these different soils will give quite different results. The response of these soils to a given fertilizer is different just as their response to a given crop is different.

Soil Differentiation

What are the main kinds of soil that occur in Quebec province? Roughly, soils may be classed as:—

(1) Fertile arable land
(2) Fertile non-arable land
(3) Poor arable land
(4) Poor non-arable land

Good, fertile, arable land may be gravelly, sandy, silty, or clay in nature, or possess varying percentages of all these fractions, or in it organic matter, in a desirable state of decomposition, may be dominant. Good natural drainage must exist, or reasonably easy artificial drainage must be possible. Large stones and boulders in any numbers must be absent. The slopes of hills must be gentle. Above all, the following desirable states must exist within the soil itself:

(1) Desirable chemical composition
(2) Proper physical condition
(3) Satisfactory biological relationships.

Of outstanding importance in determining in the soil the existence or non-existence of these desirable states are the factors of geological origin of the mineral portion of the soil, climate and topography.

Good, fertile, non-arable land may have in it great numbers of stones and boulders. Its topography may be unsuited to ordinary farm operations. Land of this class is usually naturally well drained. Some of the best apple and sugar maple orchard soils in the world may be classified as good, fertile, non-arable land.

Clay soils may be ranked among the most fertile. Our major areas of clays and silts are flat-lying or gently rolling soils occurring in wide river valleys and ancient sea-beds. Our clays have originated as sedimentation from water in past geological ages. Those soils that are very largely silt, with but little clay, are usually lower in fertility than the true clays.

The whole practice of the liming and fertilization of soils is evidence of the importance of the chemical composition of soil constituents. The desirable properties of good physical condition and of an efficient microbiological population are almost certain to follow if soils are not too low-lying, if they have good chemical composition, and if sufficient time has elapsed since their deposition, or other origin, for the reaching of equilibrium within them. When non-pervious strata exist below soils of well-balanced chemical

composition, such strata will be found to differ markedly in chemical make-up from the overlying soil. In such cases, poor drainage may be attributed to chemical deficiency existing within certain strata.

In our climate, fertility in sandy loam, sandy and gravelly soils is due to the existence of good balance in their chemical composition. In Quebec, such "light-textured" soils, as a rule, when well supplied with mineral elements will be fertile.

Poor arable lands and poor non-arable lands owe their poverty to some chemical deficiency or lack of balance. In this section of the continent they are usually sandy soils, which may or may not contain a considerable percentage of silt. Under our climatic conditions these sandy loam soils generally have in their surface few inches a high content of organic matter in a semi-decomposed and acid condition. Such soils are described elsewhere. (*3*) (*4*). There are, of course, banks and drifts of blown sand in some localities, which are practically pure fine sand, with little or none of silt, clay or organic matter present. In clay regions there will be found almost everywhere, at intervals of a few miles, higher sandy soils that in most cases should be classed as poor arable land. In the Laurentian districts, with the exception of river valley or old lake bottom soils, poor sandy lands predominate.

Known in Quebec as "Terre noire", there are large areas of black flat-lying muck soils, almost invariably resting on non-pervious tightly-packed substrata and usually ill-drained. These may be potentially very rich soils that with little expense may be fitted to bear large crops, or they may be of such a nature that the cost of bringing them to a state of fertility would be prohibitive.

There are few large soil areas in our agricultural sections where the bed rock underlying glacial or water deposits is exposed. There are some such areas, however, especially in higher lands, where disintegrating bed rocks are exercising an important effect on soils. Limestone and lime shale fragments are, of course, excellent soil-building material. Schistose rock fragments are sometimes very valuable, for example, those high in chloritic minerals, containing magnesium, or in micas, which in many cases, for example, biotite, contain both magnesium and potassium in considerable quantity. In our climate peridotite rocks, containing a high percentage of magnesium, make very good soil-building stuff. The igneous rock, syenite, which is normally almost free from quartz, makes excellent soils when its disintegrating fragments are well mixed through the soil mass. The wonderfully fertile apple orchard soils on the lower slopes of many of the Monteregian hills in Quebec owe their fertility very largely to the minerals resulting from slow decomposition of the syenite rock fragments which they contain. In Quebec province soils filled with slate or sandstone fragments are not ordinarily very fertile, although in some localities sandstones outcrop that are quite mineral-rich. Much igneous or metamorphic rock material that is high in quartz, such as the granites or gneisses, is composed of insoluble and inert minerals that do not decompose readily to enrich soils in desirable elemental fertility constituents.

The Causes of Soil Differences

The primary interlocking causes of soil differentiation are geological, topographic, climatic and biological. We do not know exactly how long it is since the great ice mass of the most recent world glacial epoch receded to its present dimensions and left the surface of the earth life-denuded, scraped, squeezed and mixed up. We know, however, that it is many thousands of years and that life adapted to our conditions has had a chance to reëstablish itself. Here in eastern Canada the surface of the world received during the glacial ages an ice and water gouging, eroding and subsequent patchy sedimentation that is still the most important single factor in the differentiation of the soils.

The topography of agricultural areas has a great influence on the nature of the soils. The steepness and direction of slope of hillsides, the height of the land above mean sea level, the direction of flow, evenness of flow and velocity of streams all play important parts in soil differentiation. Where great level or slightly rolling plains exist, as in the wide ancient flood plains of, for example, the St. Lawrence and Ottawa rivers, we have an illustration of the levelling-up processes of Nature. All the clay, silt and sand accumulations of these wide and relatively level plains result primarily from the erosion of higher, more exposed surrounding lands. In nearly all cases the present wide and level lower valleys of great rivers have been in recent and older geological ages the beds of arms of the ocean.

Climate has a great effect upon soil constitution. In cold and relatively wet climates like ours heavy leaching of some valuable mineral fertility elements occurs, especially from sandy or gravelly soils. Many poor sandy soils have quite a high accumulation of sour, semi-decomposed organic matter in their surface layers; they are strongly acid and they have lost by leaching much of whatever valuable mineral matter they may once have contained. Potentially, the high organic matter content of many of these at present infertile soils is valuable. Not only is organic carbon present in quantity in them, but so is total nitrogen in most cases, and generally in these surface soils total sulphur and total phosphorus are not greatly lacking. All of these elements, however, are tied up in almost completely unavailable form in the complex, peat-like, semi-decomposed organic matter.

The biological relationships of a soil are extremely significant. Under suitable environmental conditions of warmth, moisture, aeration and properly balanced chemical composition, soil microörganisms carry on decomposition processes within the organic matter until desirable end-products result. The valuable soil life-governed processes are discouraged and inefficient especially when the chemical composition of the soil is unbalanced. A greater amount of exact information is needed on the biological processes taking place in soils of northern climates similar to ours.

Effect of Soil Treatments

The aim of farmers is to obtain maximum crop yields, in both quality and quantity, with a minimum expenditure of money. Lime and chemical fertilizers are added to soils to supplement the constituents already present

there, but the limit of economic expenditure per acre for these materials is soon reached.

In addition to the lime and chemical fertilizer questions there are some other fundamental soil treatments about which a good deal of uncertainty appears to exist.

Depth of Ploughing

Should the depth of ploughing, for best results, be the same with all soils? It has been the writer's opportunity within the last few months to examine for lime requirement hundreds of garden soils and hundreds of field soils, of the same general types, in the province of Quebec. In practically all cases, regardless of what the soil type might be, the garden soils were neutral or nearly neutral in reaction, with very low lime requirements, or none, while in the great majority of cases the field soils had high lime requirement values. Well-rotted barnyard manure, and in a good many cases wood-ashes, had been more freely used on the garden soils than on the field soils, but in very few cases had either lime or commercial fertilizers been used. There were also many cases in which wood-ashes had not been used. Unleached wood-ashes would of course have a great effect in neutralizing soil acids. There are, however, two other points in connection with these garden soils that are worthy of consideration:

(1) Garden soils are usually ploughed and cultivated more deeply and more often than field soils and the upper soil layer through which plant roots can easily penetrate to obtain nutrients is deeper and better mixed. Moisture relationships are improved.

(2) Life is more abundant within garden soils than in field soils. Living organisms have a great effect on their environment, (*1*) and in well-fertilized and deeply cultivated garden soils beneficial organisms usually thrive and help to control acidity and its harmful effects on crop growth.

In connection with depth of ploughing it is interesting to know that the usual practice in Scotland is to plough field soils much more deeply than is customary here. Yet there are many farmers in this country also who practice deep ploughing. In Scotland, while ploughing 10 inches deep is advocated by many, 8 inches furrow depth is probably more commonly attained. Until we get our soil types in Quebec "sorted out" and fully defined it is unsafe to make too sweeping generalizations one way or the other in this connection.

Rotations, Drainage and Leguminous Crops

In this paper it is sufficient to reiterate that good rotation of crops, proper drainage of soils and the growing of leguminous crops are important factors in increasing and maintaining soil fertility.

Barnyard Manure

Animal manures are accepted by all agricultural workers as being among the most valuable of soil treatments. Life within soils is increased by the use of barnyard manure and especially by well-rotted manure, and for this reason if for no other it is valuable on our cold, inert and almost

"lifeless" infertile soils. There are some aspects of the use of barnyard manure that will bear further investigation. It is very doubtful if identical methods of application are equally good on all soil types.

Horticulturists recommend the use of well-rotted barnyard manure for application to crops. For field application some other authorities have recommended, under certain conditions, the hauling of the manure from the stables to the fields, as it is produced, to minimize losses by leaching and fermentation. In view of the extremely high organic carbon content (organic matter in a semi-decomposed state) of many of our less fertile agricultural soils, it is doubtful if it is wise to increase this by the addition of fresh, strawy manure.

It is probable that hauling fresh manure directly to the fields is a good practice on most of the heavy clays of this province; in these clays organic carbon is not usually present in the percentage at which it exists in the more infertile soils, and soil biological conditions are better. Being better balanced in mineral constituents than the less fertile sandy soils, in these soils decomposition processes go on more rapidly.

There are, of course, other factors that enter into the handling of barnyard manure, such as proper storage in order to reduce losses by leaching, and the question of availability of labour at different seasons of the year, but these factors will not be discussed here.

Liming Materials

Lime is applied to soils for three principal reasons:

(1) To increase the calcium concentration of the soil and of the soil solution.

(2) To decrease soil acidity.

(3) To better the physical condition through remedying chemical soil deficiencies.

When soils are rich in lime clover and alfalfa growth are encouraged and the nitrogen content of the soil is increased through the activity of nitrogen fixing bacteria. The average yield of crops is usually greatly increased on acid soils when lime is applied.

On many soils the application of lime is not needed: they are well enough supplied with it already. For apple growing, potato growing or tobacco growing, lime is not usually applied to soils, though it must be present to some extent in these soils that are specially suited to the growing of particular crops. It is the practically universal experience that the liming of acid soils is a well-paying practice for general farmers.

On the poor arable soils previously discussed in this paper the addition of lime in some of its forms, or of unleached wood ashes, undoubtedly aids in correcting the very acid condition of the high organic matter surface layer. By liming, the useful microörganisms effective in the decomposition of "raw" organic matter to true humus form in the soil, are encouraged. The physical characteristics of the soil are bettered by lime.

Although one of the most important means, lime is not the only means by which soils can be brought to a highly fertile state. The excellent condition

of many Quebec garden soils, including scores of sandy loam type, has previously been noted. Yet in most cases nothing but well-rotted barnyard manure and deep and thorough cultivation had been used on these soils. Quite acid soils are often exceedingly fertile. One such soil, on which alfalfa thrives, occurs on the west slope of Mount Johnson, one of the Monteregian hills. It is filled with crumbling fragments of syenite rock and this soil with a nitrogen content of 0.71 per cent in the surface 8 inches and 0.30 per cent between 16 inches and 24 inches deep has in its surface 8 inches a pH value of 5.49 and a lime requirement (by Jones' method) of 6,100 pounds of burnt lime per acre, while between 16 and 24 inches deep the pH value is 5.50 and the lime requirement 5,480 pounds of burnt lime per acre. Water-soluble phosphate phosphorus is in considerable quantity in this soil, much more being present than usually exists in neutral soils. Such a condition is unusual in acid soils. (*5*).

Chemical Fertilizers

Chemical fertilizers themselves are not "plant food" any more than hay or pasture grasses are human foods. They contain, however, the vitally necessary raw materials, in soluble form, out of which plants can synthesize their food. The complex reactions which take place between the soil and added fertilizer treatments are what condition the crop plants' response. A plant takes its nutrients from the soil solution as a very dilute stream of constituents dissolved in water. Some of the conditions governing the concentration of this dilute stream of nutrients do not fall within the scope of this paper for discussion. ("Base exchange" and "soil absorption complexes" are subjects fully dealt with in any up-to-date textbook on soils.) Too low concentration of this dilute stream of nutrients for optimum plant development is the common trouble on the majority of our Quebec farm lands. Optimum concentration of the soil solution for plant growth is only attained in soils that are in the very best chemical, physical and biological condition. It may safely be said that the use of chemical fertilizers is one of the best and most economical ways of helping to bring about this optimum condition.

Chemical fertilizers may be used alone or to excellent advantage to supplement lime and barnyard manure.

In pasture fertilization work at the Fredericton Experimental Station in Canada, (reported annually during the last few years by the superintendent, Mr. Bailey), in many places in the British Isles and in the New England States, the use of chemical fertilizers by themselves to stimulate pasture grass growth, is giving splendid returns. The fertilizers are applied on the sod and increased growth rate and quality of grass result. Superphosphate and basic slag appear to give greatest results in encouraging the growth of desirable pasture grass species, but available nitrogen and potassium salts are also necessary to maintain quality in the greatly increased yield of grass. To the special crops mentioned on the first page, on which chemical fertilizers may be used with very excellent results, we must add one of the most valuable general agricultural crops of all—young grass.

There are some practical questions that must be answered in the use of chemical fertilizers to best advantage on any crop. Such questions as

time of application, depth to drill or "cultivate in", the best paying quantities to use, broadcasting or row application, and so forth, are important practical points that will be found to differ with each crop and each soil and with each fertilizer material.

Depending upon soil conditions and upon their own nature, chemical salts added as fertilizer will more or less readily leach out of the soil and be lost in drainage water, or they will be absorbed and held by the soil. Both phosphatic fertilizers and potash salts react with the soil and there is ordinarily but little of either phosphorus or potassium lost in leaching. The valuable part of nitrogen-carrying fertilizer salts may or may not leach readily from the soil, depending on the form in which the nitrogen is present. It may safely be emphasized, however, that plants benefit from fertilizer applications directly as soils benefit therefrom.

The specific functions of the different fertilizing elements, in their varying forms as different chemical salts, are fully, simply, and very ably discussed (6) by Russell.

Summary

It is the final balance existing in the soil after the addition of soil treatments that is important, rather than the use of "balanced fertilizers". Without knowledge of fundamental soil conditions the most economical use of barnyard manure, lime and chemical fertilizers cannot be secured. Sweeping conclusions that similar results may be obtained from the use of similar treatments on all "light" (sandy) soils or on all "heavy" (clay) soils are unwarranted. In this paper soil differences are emphasized as well as the principal factors effecting differentiation under Quebec conditions.

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RAPPORT ENTRE LE NOMBRE ET LA QUALITE DES BACTERIES ET LEUR DEVELOPPEMENT ULTERIEUR DANS UN LAIT PUR ET UN LAIT CONTAMINE*

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Introduction

La bactériologie du lait n'est plus maintenant une science nouvelle puisqu'il y a déjà au-delà d'un quart de siècle que des recherches sont faites sur le sujet et dans plusieurs pays. Russell, dès 1894, démontrait par des expériences la fausseté de l'opinion courante vers cette époque que le lait au sortir du pis de la vache est complètement exempt de bactéries. Ces expériences ont été répétées depuis et il est maintenant prouvé que le lait contient toujours un certain nombre de germes quelles que soient les méthodes aseptiques employées pour l'extraire de la mamelle. Cependant, le plus grand nombre de bactéries que l'on rencontre dans le lait commercial ne proviennent pas de la vache directement, mais bien plutôt des divers agents de contamination durant la manipulation du lait, et de leur développement ultérieur lorsque la température y est favorable.

Ayers, Cook et Clemmer en 1918 ont fait des recherches extensives sur les principales causes de contamination du, lait et les ont classifiées par degré d'importance dans l'ordre suivant: ustensiles non stérilisés, vaches malpropres et chaudières à trop grande ouverture pour la traite. Ces mêmes auteurs concluent positivement que "it is absolutely necessary, if milk is held on the farm, to keep it near 50°F or lower, in order to restrain bacterial growth, if the dairyman wishes to market milk of low bacterial content."

Il y a aussi un autre facteur, en outre de la température, qui tend à diminuer l'augmentation des bactéries dans le lait, et c'est l'action bactéricide du lait proprement dit. Diverses théories ont été avancées fréquemment pour expliquer cette action mais Jones et Little, en 1930, ont réussi à séparer cette substance du lait qu'ils ont réduite en poudre et à laquelle ils ont donné le nom de "Lacténine". Le refroidissement du lait a non seulement pour effet de retarder directement le développement des germes, mais aussi de prolonger l'action de cette substance bactéricide.

Quoique le nombre de bactéries soit un facteur très important dans la conservation du lait, il est certainement surpassé par les espèces de germes présents, puisque la qualité des bactéries détermine dans un lait le genre de décomposition qui pourra s'y opérer. Dans le pis d'une vache normale il est démontré que le nombre d'espèces de bactéries est très limité. Harding et Wilson en 1913 concluent d'une étude de 900 échantillons de lait que les microcoques constituent 75 pour cent des espèces présentes dans le pis. Conn et Stocking (1903), Wolff (1908) et Luxwolda (1911) ont tous démontré par des expériences que le développement des bactéries productrices d'acide est tellement rapide à la température de 70°F, qu'il empêche la croissance de toutes les autres espèces. Lorsque le lait est maintenu à la température de 50° F. ou au-dessous, les espèces alcalines constituent le plus large groupe.

*Extrait d'une thèse de Doctorat en Sciences Agricoles présentée à l'Université de Cornell, Ithaca, N.Y.

Il est facile de concevoir que la température est le facteur le plus important pour contrôler la flore bactérienne du lait tant au point de vue quantitatif que qualitatif. Il est surprenant de constater toutefois que la plupart des recherches faites sur la qualité des espèces bactériennes du lait l'ont été en rapport avec la température et qu'aucune attention n'a été portée sur les sources de contamination. Au point de vue quantitatif, Ayers, Cook et Clemmer (1918) furent les seuls à montrer l'importance de la contamination sur l'augmentation relative des bactéries dans un lait maintenu à diverses températures. Ils ont procédé en variant les conditions de propreté à l'étable pour la traite. Nous avons poursuivi une série d'expériences pour montrer l'étendue de cette influence en contaminant le lait directement avec une quantité définie de fumier et de sol. Dans une autre série d'expériences, nous avons étudié l'influence de l'action germicide du lait sur ces mêmes contaminations. Enfin, dans une troisième série nous avons étudié les espèces de bactéries dans le lait traité de la même façon.

Etude Quantitative

1ère partie. Effet de la contamination sur le développement des bactéries dans un lait maintenu à diverses températures.

Méthode. Les échantillons de lait étaient pris à l'étable de l'Université immédiatement après la traite qui était faite dans des ustensiles stérilisés; ils étaient ensuite apportés immédiatement au laboratoire. Ils constitueront pour notre discussion les échantillons de lait pur. 20 centimètres cubes de lait étaient mesurés au moyen d'une pipette dans un vase et gardés comme contrôle. Un autre vase contenant la même quantité de lait était contaminé comme suit: 1 gr. de fumier était dilué dans 99 centimètres cubes d'eau stérilisée et aprés agitation. 0.2 de centimètre cube de cette suspension étaient ajoutés aux 20 centimètres cubes de lait.

Les contaminations avec le sol étaient faites de la même façon en employant les mêmes proportions mais non simultanément, c'est-à-dire à une différente période de l'année. Aussitôt après la contamination, les deux échantillons—lait pur et lait contaminé—étaient mis en culture dans des vases de pétrie et incubés à 37 degrés C. pendant 48 heures. Trois dilutions étaient faites pour chaque échantillon et en plus chaque dilution était faite en duplicata. Le milieu de culture employé était l'agar-agar avec un p.H. de 6.8 auquel était ajouté 1% de lactose.

Les échantillons de lait étaient ensuite divisés en deux et incubés à deux différentes températures, l'un à une température variant entre 43 et 50° F. et l'autre entre 55 et 63° F. Les échantillons incubés à la plus basse température étaient mis en culture à nouveau après 2 et 3 jours. Ceux incubés à la température la plus élevée n'étaient mis en culture qu'une fois après deux jours d'incubation.

(A) Augmentation relative des bactéries dans le lait pur et le lait contaminé avec du fumier.

Les résultats ci-dessous représentent la moyenne de douze expériences. Il est curieux de constater qu'avec 2 échantillons contenant à peu près le même nombre de bactéries il y a multiplication deux fois plus rapide dans le lait

contaminé avec du fumier que dans le lait pur quoique le nombre de bactéries ajoutées ne représente en moyenne que 1785 bactéries par centimètres cubes.

	Nombre de bactéries par c.c.		*Temp. 55-63° F.*
	Au début	*Après 2 jours*	*Rapport de croissance*
Lait pur	11745	12261666	1044
Lait et fumier	13420	25290000	2153

	Temp. 43-50° F.				
	Au début	*Après 2 jrs*	*Rapport de croissance*	*Après 3 jrs*	*Rapport de croissance*
Lait pur	11745	106687	9.06	992833	84.5
Lait et fumier	13420	135275	10.07	1473083	109.7

Lorsque le lait est maintenu à une température inférieure à 50°F. les bactéries dans le lait contaminé ne semblent pas se développer plus rapidement que celles présentes dans le lait pur durant les 2 premiers jours de l'incubation. Cependant, si le lait est maintenu au-delà de 2 jours à la même température, les bactéries du lait contaminé tendent à montrer une plus rapide croissance comme on peut le constater par la 5ième colonne du tableau précédent. Ce rapport de croissances est obtenu en divisant le nombre de bactéries après la période d'incubation par le nombre initial.

Ces résultats montrent que la contamination du lait même avec une très faible quantité de fumier non seulement augmente le nombre initial des bactéries mais occasionne un développement plus rapide de ces mêmes bactéries lorsque le lait est conservé durant quelques jours.

Comme on pourrait s'y attendre, la différence n'est pas aussi prononcée lorsque le lait est maintenu à une basse température. D'où l'on voit l'importance de bien refroidir le lait.

(B) Augmentation relative des bactéries dans le lait pur et le lait contaminé avec du sol.

Ici encore les résultats donnés ci-après représentent une moyenne de douze expériences. Nous pouvons constater aussi une plus rapide croissance des bactéries que dans la première série d'expériences parce que la température de la chambre d'incubation s'est maintenue un peu plus élevée en moyenne. Et il est intéressant de noter que le développement des bactéries dans le lait contaminé fut plus que le double de celui du lait pur, ce qui nous porterait à croire que plus la température est élevée plus les bactéries d'un lait contaminé surpassent dans leur développement celles d'un lait pur. Il se peut aussi que la différence soit due aux genres de bactéries provenant du sol et du fumier.

	Nombre de bactéries par c.c.		*Temp. 58 à 63° F.*
	Au début	*Après 2 jours*	*Rapport de croissance*
Lait pur	9465	48791666	5154
Lait et sol	10912	132629166	12153

	Temp. 43-50° F.				
	Au début	*Après 2 jrs*	*croissance*	*Après 3 jrs*	*croissance*
Lait pur	9465	68120	7.19	593781	62.7
Lait et sol	10912	47785	4.19	1437516	131.7

Il est curieux de constater qu'à une température inférieure à 50°F. les bactéries d'un lait contaminé avec du sol non seulement se développent moins rapidement que celles d'un lait pur après une incubation de 2 jours.

mois leur nombre est aussi moindre. Une explication possible de ce phénomène serait que les bactéries provenant du sol préviennent jusqu'à un certain degré le développement des autres organismes et sont retardées dans leur propre croissance par la température et probablement aussi par l'action germicide du lait. Lorsque l'incubation se prolonge audelà de 2 jours, les conditions sont renversées et les bactéries dans le lait contaminé se développent deux fois plus rapidement que celles du lait pur. Il est possible que dans ce cas les organismes du sol qui ont survécu à l'action bactéricide du lait se développent plus rapidement que ceux présents dans le lait pur.

(C) Comparaison entre l'effet de la contamination provenant du fumier et celle provenant du sol sur le développement des bactéries dans le lait.

Afin de montrer plus clairement cette influence relative de la contamination avec du fumier ou du sol, nous avons computé les rapports entre le nombre de bactéries dans le lait pur, dans le lait contaminé avec du fumier et dans le lait contaminé avec du sol. Ces rapports sont calculés simplement en divisant le nombre de bactéries des laits contaminés par celui du lait pur, ce dernier étant alors pris comme unité.

	Au début	*Après deux jours*		*Après 3 jours*
		43-50° F.	*55-62° F.*	*43-50° F.*
Lait pur	1.00	1.00	1.00	1.00
Lait et fumier	1.14	1.26	2.06	1.48
Lait et sol	1.15	0.67	2.71	2.42

Le rapport entre le nombre de bactéries d'un lait pur et d'un lait contaminé avec du fumier varie de 1.00 : 1.14 au temps de la traite à 1.00 :2.06 après que le lait a été gardé pendant deux jours à une température d'environ 60 F. L'effet est encore plus prononcé si la contamination est faite avec du sol. Il est évident que la température a une plus grande influence sur le nombre de germes que la contamination mais le tableau ci-dessus montre que même à une température au-dessous de 50° F. le rapport entre le nombre de bactéries d'un lait pur et d'un lait contaminé avec du fumier varie de 1.00 : 1.14 au temps de la traite à 1.00 : 1.48 après une période de trois jours. Avec le sol les rapports sont de 1.00 : 1.15 et 1.00 : 2.42.

Ces chiffres montrent que les organismes provenant du sol se développent plus rapidement dans le lait que ceux provenant du fumier, excepté durant les deux premiers jours lorsque la température est maintenue au-dessous de 50° F. La conclusion à tirer de cette série d'expériences serait que la contamination du lait avec du fumier et du sol non seulement augmente le nombre initial des bactéries mais engendre un plus rapide développement lorsque le lait est conservé durant quelques jours. Et cette augmentation semble plus prononcée avec un élévation de température.

(*2 ème partie*)

Influence de l'action germicide du lait sur le développement relatif des bactéries suivant la source de contamination.

Les échantillons de lait dans cette série d'expériences furent prélevés de la même façon que dans les expériences précédentes. Immédiatement après le prélèvement, l'échantillon était divisé en deux parties et une partie placée durant 24 heures dans une chambre froide variant de 45° à 48° F.

L'autre moitié était de nouveau divisée en trois portions, l'une d'elles constituant le lait pur et les deux autres étaient contaminées avec du fumier et du sol respectivement en suivant la même procédure que dans les expériences plus haut mentionnées.

Immédiatement après la contamination, les trois portions—lait pur, lait contaminé avec du fumier, et lait contaminé avec du sol—étaient mises en culture sur l'agar-agar et ensuite divisées de nouveau afin de les incuber à deux températures différentes. Ces mêmes échantillons étaient de nouveau mis en culture après 2 jours pour les portions incubées à une température de 60—65° F. et après 3 jours pour celles incubées à 48—50° F.

Meier (1922) a trouvé que l'action germicide du lait ne se fait plus sentir lorsque ce dernier est maintenu à 57° F. pendant 21 heures. Nous avons alors estimé qu'à la température de 45—48° F., cette propriété du lait est complètement détruite ou à peu près après 24 heures d'incubation. Cette partie de l'échantillon refroidie pendant 24 heures était alors soumise au même traitement que la première contaminée immédiatement après la traite. Pour la facilité de notre discussion, la portion contaminée immédiatement après la traite constituera le lait *frais* et l'autre le lait *refroidi*.

Le milieu de culture et les conditions d'incubation furent exactement les mêmes que dans les expériences précédentes.

(A) Rapport entre le développement des bactéries d'un lait contaminé immédiatement après la traite et d'un lait contaminé après une journée de refroidissement.

Nombre de bactéries par c.c.

Au début		*Après 2 jours à 60-65° F.*		*Rapport de croissance*	
Frais	Refroidi	Frais	Refroidi	Frais	Refroidi
L.P.* 2032	2274	23035550	47705550	11336	20539
L.F. 33795	58005	86744400	73172220	2567	1261
L.S. 2387	2618	37611110	58311110	15752	22273

Au début		*Après 3 jours à 48-50° F.*		*Rapport de croissance*	
Frais	Refroidi	Frais	Refroidi	Frais	Refroidi
L.P. 2032	2274	4417660	15922200	2174	7001
L.F. 33795	58005	5008500	21853330	148	376
L.S. 2387	2618	6363050	23415550	2665	8944

*L.P. — Lait pur
L.P. — Lait et fumier
L.S. — Lait et sol

Ces chiffres représentent une moyenne de 9 expériences.

Nous avons vu précédemment qu'un lait contaminé avec du fumier entraine développement plus rapide des bactéries qu'un lait pur. Le tableau précédent semblerait contredire cet énoncé lorsque la température est maintenue aux environs de 60° F. Il faut cependant considérer que le nombre de bactéries est de beaucoup plus élevé dans le cas du lait contaminé avec du fumier que dans le cas du lait pur; il est probable alors que les bactéries avaient dépassé leur période de croissance maxima et que cette dernière s'opérait plus lentement lorsque le comptage fut fait. Il appert aussi dans le même tableau que le rapport de croissance dans le lait *frais* contaminé avec du fumier est plus que le double de celui du lait *refroidi* lorsque la température est maintenue à 60° F. Il semblerait alors que les propriétés germicides

du lait n'ont aucun effet sur les germes provenant du fumier et que les changements apportés par les bactéries présentes, dans le lait durant les 24 heures de refroidissement sont plus nuisibles aux bactéries du fumier que l'action bactéricide du lait proprement dit. Il se pourrait aussi que les bactéries présentes dans le lait aient souffert ce qu'on appelle un "cold shock" durant le refroidissement et qu'ensuite pendant une incubation de 2 jours à 60° F. elles n'aient pas eu le temps de se développer aussi rapidement que celles présentes dans le lait *frais*. Cette dernière explication semblerait plus plausible puisque le rapport de croissance du lait *refroidi* contaminé avec du fumier est de beaucoup supérieur à celui du même lait *frais* après une période d'incubation de 3 jours à une température inférieure à 50° F.

Dans le cas du lait contaminé avec du sol les résultats sont plus consistants qu'avec le fumier et le rapport de croissance du lait *refroidi* est de beaucoup plus élevé que celui du lait *frais*, peu importe la température d'incubation employée. Ces résultats sembleraient donc indiquer que la contamination du lait après un certain temps suivant la traite favorise une croissance plus rapide des bactéries qu'une contamination immédiatement après la traite si, dans les deux cas, le lait est maintenu à une température ne dépassant pas 50° F. Si cependant le lait est conservé à une température aux environs de 60° F. l'action germicide du lait semble avoir un effet moindre que la température.

(B) Influence relative de l'action germicide du lait sur la croissance des bactéries dans un lait pur et un lait contaminé.

Lorsque nous étudions l'influence des propriétés bactéricides du lait sur la croissance bactérienne d'un lait contaminé avec du sol ou du fumier nous devons aussi prendre en considération cette influence sur le même lait non contaminé car la croissance plus rapide dans le lait *refroidi* et contaminé peut être due simplement aux bactéries déjà présentes dans le lait pur et les organismes ajoutés par la contamination peuvent se comporter envers l'action bactéricide du lait de la même façon que les organismes déjà présents.

Rapports entre le nombre de bactéries du lait *frais* et du lait *refroidi*.*

	Au début	*Après 2 jours à 60-65° F.*	*Après 3 jours à 48-50° F.*
Lait pur	1.00 : 1.11	1.00 : 2.07	1.00 : 3.60
Lait et fumier	1.00 : 1.71	1.00 : 0.84	1.00 : 4.36
Lait et sol	1.00 : 1.09	1.00 : 1.55	1.00 : 3.67

*Le nombre de bactéries dans le lait *frais* est pris comme unité.

Par les résultats ci-haut nous pourrions conclure que l'action germicide du lait a à peu près le même effet sur les organismes du sol et du fumier que sur ceux du lait pur. Nous pouvons constater en effet que le rapport entre le nombre de bactéries du lait *frais* et du lait *refroidi* varie dans les mêmes proportions pour le lait pur et le lait contaminé lorsque ces laits sont gardés durant 3 jours à une température inférieure à 50° F.

A peu près le même rapport existe lorsque le lait est maintenu durant 2 jours à une température de 60-65° F. excepté avec le lait contaminé avec du fumier; cette différence est due probablement, tel qu'expliqué précédem-

ment, au nombre très élevé de bactéries au début. Cette augmentation du nombre de bactéries dans le lait *refroidi*, même dans le cas du lait pur, montre clairement la présence d'une action germicide du lait, et ces résultats nous porteraient à conclure que l'époque à laquelle la contamination a lieu ne semble avoir aucune influence sur le développement ultérieur des bactéries.

Notre conclusion cependant ne peut être générale, puisque nous avons trouvé des variations assez prononcées entre les différentes expériences et un comptage des bactéries à toutes les 6 ou 12 heures nous aurait donné une bien meilleure idée de cette action germicide. De plus la quantité de contamination, telle que montrée par Basenau en 1894, changerait probablement à un certain degré l'influence de cette action bactéricide du lait.

Etude Qualificative

Influence de la contamination et de la température sur la qualité de la flore bactérienne du lait.

Les échantillons furent préparés de la même façon que dans les expériences précédentes en employant aussi les mêmes sources de contaminations et le même milieu de culture. Une moyenne de 50 à 60 colonies provenant de chaque échantillon étaient transférées séparément dans des tubes à épreuve contenant du lait stérilisé additionné de tournesol. Ces cultures pures étaient incubées à 37°C. pendant une semaine et ensuite à la température ordinaire pendant une dizaine de jours. Ces organismes étaient ensuite classés en cinq groupes d'après leur réaction dans le lait additionné de tournesol. Le groupe producteur d'acide seulement comprenait toutes les cultures changeant le tournesol au rouge sans causer la coagulation du lait. Ceux causant une coagulation acide du lait constituaient le deuxième groupe. Les cultures causant une digestion partielle ou complète du lait formaient le groupé des bactéries liquéfiantes. Le groupe alcalin comprenait tous les organismes changeant le tournesol au bleu sans causer aucun changement apparent dans la composition du lait. Enfin tous les autres organismes ne produisant aucune modification apparente du lait ou du tournesol formaient le group des bactéries inactives.

Pourcentages des différents groupes d'organismes.

		Lait pur	Lait et fumier	Lait et sol
Groupe acide	Au début	53.60%	52.66%	54.42%
	2 jrs à 58-65°F.	19.13	22.48	16.18
	3 jrs à 42-50°F.	45.35	41.07	42.39
Groupe coagulant	Au début	10.38	9.19	6.66
	2 jrs à 58-65°F.	35.06	41.77	38.28
	3 jrs à 42-50°F.	23.81	16.69	6.02
Groupe liquéfiant	Au début °	11.32	13.54	13.01
	2 jrs à 58-65°F.	15.15	20.46	17.00
	3 jrs à 42-50°F.	17.77	23.08	32.50
Groupe alcalin	Au début	4.10	6.22	5.18
	2 jrs à 58-65°F.	17.05	12.46	16.89
	3 jrs à 42-50°F.	8.08	14.42	10.17
Groupe inactif	Au début	20.53	19.11	20.61
	2 jrs à 58-65°F.	13.53	2.90	11.58
	3 jrs à 42-50°F.	4.05	4.39	8.82

Chacune de ces cultures pures était aussi étudiée au microscope, les préparations étant faites par la méthode de Gram. Cette étude au microscope était limitée à la morphologie générale des organismes que nous avons classifiés en trois grands groupes; les Staphylocoques, les Streptocoques et les Batonnets, le premier groupe comprenant toutes les formes sphériques excepté les Streptocoques.

Le tableau ci-haut représente une moyenne de 6 expériences et nous avons trouvé que les types de bactéries présentes dans le lait pur varient plus entre les différents échantillons que les changements apportés par la contamination. L'addition de 0.1 gramme de fumier ou de sol à un litre de lait n'apporte pas grand changement dans les divers groupes de bactéries, les variations étant au plus de dix pour cent immédiatement après la contamination.

Après une incubation de 2 jours à la température de 58-60° F. la flore bactérienne du lait a beaucoup changé. La diminution du pourcentage des bactéries productrices d'acide fut accompagnée d'une augmentation correspondante des bactéries coagulantes. Nous pouvons constater par le tableau précédent que la contamination du lait avec du fumier ou du sol a un effet beaucoup moindre que la température sur le développement des différents types d'organismes, et nous pourrions conclure que les bactéries apportées au lait par la contamination produisent à peu près les mêmes réactions et sont affectées par la température de la même façon que celles déjà présentes dans le lait.

Lorsque le lait est maintenu durant 3 jours à une température inférieure à 50° F., le changement dans les différents types d'organismes n'est peut-être pas aussi prononcé mais plus général, puisqu'il y a augmentation des bactéries coagulantes, liquéfiantes et productrices d'alcali au détriment des bactéries acides et inactives. La contamination à cette température a une plus grande influence sur le pourcentage des différents types d'organismes que lorsque le lait est maintenu à 60° F. pendant 2 jours. Et cet effet est encore plus prononcé avec les bactéries du sol qu'avec celles du fumier puisqu'avec celles-là les bactéries coagulantes ne présentent aucune augmentation tandis que les bactéries liquéfiantes et productrices d'alcali montrent une augmentation d'au-delà de 50% sur celles présentes dans le lait frais.

Pourcentage moyen des types morphologiques de bactéries.

		Staphylocoques	Streptocoques	Batonnets
Au début	Lait pur	80.59%	16.21	3.17
	Lait et fumier	67.98	21.58	10.37
	Lait et sol	71.81	10.60	17.54
Après 2 jrs à 58-60°F.	Lait pur	16.81	48.00	35.17
	Lait et fumier	10.02	54.80	35.30
	Lait et sol	17.36	49.15	33.45
Après jrs à 42-50°F.	Lait pur	9.57	28.59	61.78
	Lait et fumier	16.66	31.73	51.56
	Lait et sol	24.84	28.99	46.11

Puisque nous avons trouvé aussi de grandes variations entre les différents échantillons de lait, il semblerait presque impossible de déterminer la frai-

cheur d'un échantillon de lait par les réactions produites dans ce lait par les organismes présents. Il semblerait plus logique de faire cette détermination par l'étude microscopique en établissant le pourcentage des différentes formes présentes, tel que montré dans le tableau suivant;

Nous pouvons constater que dans un lait frais la contamination apporte de plus grands changements dans les formes bactériennes que dans leur action sur le lait tel que montré dans le premier tableau. Il semblerait alors que les variations dans les espèces de bactéries ne sont pas en rapport direct avec leur action sur le lait. Il n'en est plus de même cependant après une certaine période d'incubation puisqu'à la température d'environ 60°F. les laits contaminés ne présentent pas beaucoup de différence avec le lait pur. Il se peut que les espèces apportées par la contamination n'aient pas trouvé les conditions favorables pour une croissance rapide.

Après une incubation de 3 jours à une température inférieure à 50°F., la contamination ne semble avoir aucun effet sur les streptocoques mais les staphylocoques présentent une augmentation assez prononcée avec une diminution correspondante des batonnets. Il est évident cependant que la température a une influence beaucoup plus grande que la contamination sur les espèces bactériennes du lait.

Il nous parait raisonnable, cependant, de conclure que la contamination du lait avec du fumier ou du sol ne change pas beaucoup sa flore bactérienne par la suite lorsque la température est maintenue aux environs de 60°F. A une température inférieure à 50°F. la contamination tend à augmenter le pourcentage des bactéries liquéfiantes et productrices d'alcali et cette augmentation semble due presque exclusivement aux staphylocoques au détriment des batonnets.

Conclusions

1—La contamination du lait avec du fumier ou du sol non seulement augmente le nombre initial des bactéries mais cause un plus rapide développement de ces mêmes bactéries lorsque le lait est conservé durant quelques jours; plus la température est élevée, plus cette augmentation est prononcée.

2—L'espace de temps écoulé entre la traite et la contamination ne semble avoir aucune influence appréciable sur le développement ultérieur des bactéries.

3—Une contamination à raison de 0.1 gramme par litre ne semble pas causer beaucoup de changements par la suite dans la qualité de la flore bactérienne du lait lorsque la température est maintenue aux environs de 60°F. A une température inférieure à 50°F. il y a augmentation relative des bactéries liquéfiantes et celles productrices d'alcali, due principalement aux staphylocoques.

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REUNION DE LA SECTION DE QUEBEC

Le 8 janvier, les techniciens agricoles de la section de Québec donnèrent un grand banquet en l'honneur de leur confrère, l'honorable Adélard Godbout. Mgr. Filion, recteur de l'Université Laval, profita de la circonstance pour décerner à ce brillant ancien élève de l'Université le diplôme de Docteur en Sciences Agricoles "honoris causa".

Après la santé du Roi, le président M. Narcisse Savoie, Chef du Service des Agronomes, souhaita la bienvenue à tous et particulièrement à l'hôte d'honneur, à l'honorable M. Tachereau, à Mgr. Filion, et leur dit combien son association était heureuse de les recevoir. Rappelant le souvenir des Caron, des Turgeon et des Perron il fit, en termes choisis, l'éloge de ces trois grands hommes.

Le Dr Langelier fut ensuite invité à nous donner sa causerie sur l'importance de l'enseignement supérieur. Le conférencier traita son sujet avec toute la compétence qu'on lui connait.

Mgr. Filion, recteur de l'Université Laval, fut l'orateur suivant et prit la parole en ces termes: "Je remercie M. le Président de son invitation qui me fournit l'occasion d'offrir mes hommages à l'hon. M. Godbout. L'Université Laval a eu l'honneur et le grand avantage de compter le nouveau ministre de l'Agriculture au nombre de ses professeurs. L'honorable Ministre à bien voulu accepter le diplôme de Docteur en Sciences Agricoles "honoris causa". J'ai cru que la présente démonstration en son honneur était une occasion propice de lui remettre son parchemin. L'Université est heureuse de reconnaître son dévouement à l'enseignement agricole, et c'est un grand plaisir pour le Recteur de l'institution de remettre au ministre de l'Agriculture le parchemin de docteur en agriculture "honoris causa."

M. Godbout reçut son parchemin au milieu des acclamations générales et prit ensuite la parole: "Mon premier devoir, je pense, est de remercier Mgr. Filion de l'honneur inattendu qu'il veut bien me faire au nom de l'Université. Je vous remercie, Monseigneur, au nom de mes confrères, parce que je sais que c'est mon nom d'Agronome que vous voulez honorer."

M. Godbout remercia ensuite M. Savoie et ses confrères. Il donna à ces derniers de précieux conseils sur la mission importante qu'ils ont à remplir. Il rappela les difficultés auxquelles les agronomes eurent à faire face au début, méfiance des cultivateurs, campagnes de certains marchands, etc. . . Ces difficultés sont à peu près disparues, mais, Techniciens, n'oubliez pas qu'il vous faut travailler encore pour aider le cultivateur à résoudre le problième agricole. L'orateur parlant ensuite de l'évolution de la science agricole, appuya sur l'importance des écoles bien outillées et des élèves bien préparés.

En terminant, le ministre de l'agriculture remercia le Dr Langelier et dit après avoir parlé de la nécessité d'une élite agricole: "Quand l'essor de l'agriculture est assuré dans une province, il n'y a pas à douter de l'avenir de cette dernière, et c'est pourquoi je suis optimiste sur l'avenir de la mienne."

L'Honorable M. Tachereau, M. Camilien Houde, chef de l'opposition, le Dr. W. T. Macoun, M. H. L. Trueman prirent aussi la parole. M. Georges Maheux remercia les orateurs avec tout le tact qu'on lui connait.

A la table d'honneur on remarquait, outre les personnes déjà nommé l'hon. J. E. Perrault, ministre de la Voirie et des Mines, l'hon. J. N. Francoeur, ministre des Travaux Publics et du Travail, le Dr. A. T. Charron, sous-ministre adjoint de l'Agriculture à Ottawa, l'abbé W. Cannon, sécrétaire de l'Université, l'abbé H. Bois, directeur de l'Ecole d'Agriculture de Ste-Anne de la Pocatière, le Dr. H. Barton, Principal du Collège Macdonald, M. Aldéric Lalonde, président de l'U.C.C.

DEUX CONFRERES HONORES PAR L'UNIVERSITE DE MONTREAL

Nous sommes très heureux d'apprendre que nos amis J. H. Lavoie, Chef du Service d'Horticulture à Québec, et Georges Maheux, Entomologiste provincial, viennent d'obtenir le diplôme de licenciés ès-sciences agricoles de l'Université de Montréal, par l'intermédiaire de l'Institut Agricole d'Oka. Les honneurs déjà reçus et les nombreux ouvrages publiés par les deux candidats furent hautement appréciés par les comités de professeurs chargés d'examiner la proposition.

Les deux nouveaux gradués ont déjà occupé diverses fonctions dans la C. S. T. A. M. J. H. Lavoie est actuellement vice-président de la Section de Québec, et M. G. Maheux membre du Conseil de Rédaction de la Revue Agronomique. Il y a donc longtemps que tous deux sont des nôtres, et les techniciens agricoles du Canada, par l'intermédiaire de la Revue Agronomique sont heureux de leur adresser de cordiales félicitations.

CONCERNING THE C.S.T.A.

Notes and News

Dr. William Allen (Saskatchewan '22) of the Farm Management Department, University of Saskatchewan, attended the meetings of the American Association for the Advancement of Science at Cleveland, Ohio, held during the latter part of December.

R. H. Hanford, (Manitoba '30) Junior Entomologist at the Dominion Entomological Laboratory, Treesbank, Manitoba, is studying for the winter months with Mr. K. M. King at the Dominion Laboratory of Entomology, Saskatoon, Sask.

Ellis MacMillan (Saskatchewan '27) of the Dominion Laboratory of Entomology, Saskatoon, has left to continue graduate studies at the University of California, Berkley, Calif.

W. J. Thomson (Alberta '26) has been appointed District Agriculturist, at Grande Prairie, Alberta.

W. L. Gordon (McGill '24) who has been taking graduate work at the University of Wisconsin, has returned to the Dominion Rust Research Laboratory, Winnipeg, Man.

Walter Jones (California '29) of the Dominion Laboratory of Plant Pathology, Saanichton, B.C., has changed his address to Cwmere, Felinfach, S. O. Cardiganshire, England.

Robert Raynauld (McGill '26) has been appointed General Manager of the Société d'Expertise Agricole. Mr. Raynauld has also been made Technical Advisor for the Losa Company of Canada Ltd., a Belgian firm with the Canadian branch situated at Toronto. His house address is 1010 Ste. Catherine St. E., Montreal.

S. F. Beliveau (Montreal '19) has changed his address to Department of Agriculture, Plessisville, P.Q.

J. Mitchell (Saskatchewan '24) is on a year's leave of absence from the Soils Department, University of Saskatchewan and is working on his doctor's thesis on, "Base exchange properties of soil organic matter," under the direction of Prof. E. Truog of the University of Wisconsin.

J. B. Munro (Toronto '19), Deputy Minister of Agriculture for British Columbia, received his master's degree from the University of British Columbia in September 1930. Mr. Munro's thesis was on "Some Native Forage Plants and their usefulness in Range Conditions."

Applications for Membership

The following applications for regular membership have been received since December 1, 1930.

Hadley, S. T. (Manitoba, 1930, B.S.A.), Winnipeg, Man.

Bergsteinsson, H. N. (Manitoba, 1930, B.S.A.), Winnipeg, Man.

Beaudet, L. (McGill, 1924, M.Sc.), St. Hyacinthe, P.Q.

Shearer, J. C. (Toronto, 1929, B.S.A.), Brampton, Ont.

1. R. P. Longley
2. H. C. Moss
3. R. D. Sinclair
4. D. F. Putnam
5. R. C. Russell

The T. Eaton Company Agricultural Research Scholarships

Awarded to Members of the Canadian Society of Technical Agriculturists in 1930.

1. R. P. Longley, graduated from McGill University in 1930. His interest is in the field of economics and he has been engaged on survey work in the Annapolis Valley of Nova Scotia and on the cost of milk production in the Montreal district. He is taking his scholarship work at the University of Toronto.

2. H. C. Moss received his B.S.A. from Saskatchewan in 1924. Since that time he has started graduate work in soils and has been employed on soil survey and laboratory work. He is doing his scholarship work in the University of Alberta, his particular problem being concerned with the soils that have developed on wooded lands in Saskatchewan.

3. R. D. Sinclair graduated from University of Alberta in 1918 and became instructor in Farm Management and Animal Husbandry at the Olds School of Agriculture. For two years he was Associate Editor of the Farmer's Advocate. Since 1922 he has been Associate Professor of Animal Husbandry at the University of Alberta. He received his master's degree from Iowa State College in 1926. Professor Sinclair was awarded a special scholarship enabling him to take up animal nutrition work at the Rowett Research Institute, Bucksburn, Aberdeen, Scotland.

4. D. F. Putnam graduated from the University of Toronto in 1927 and in 1929 started graduate work at McGill University in plant pathology. He has been employed at the Dominion Laboratory, Kentville, Nova Scotia. He is taking his scholarship work in the Department of Botany at the University of Toronto.

5. R. C. Russell graduated from the University of Saskatchewan in 1924, receiving his Master's degree in 1926. He has been Assistant Plant Pathologist in the Dominion Laboratory of Plant Pathology at Saskatoon since 1925. In 1928 he was one of the first men awarded a T. Eaton Scholarship and he entered Toronto to study the problem of, "take-all," one of the most formidable root rots of wheat in Western Canada. In 1930 he was awarded a second scholarship and is now continuing work towards his doctor's degree.

Research Scholarships for 1931-32

The C.S.T.A. is not in a position to make definite announcements regarding scholarships for the next academic year. The very generous grants from the T. Eaton Company covered a three year agreement which terminated with the awards last year. Negotiations are under way with several firms and individuals regarding the establishment of scholarship funds and it is expected that a definite announcement will be made in the March issue of *Scientific Agriculture*.

Grindley Memorial

The committee appointed at the tenth annual convention has considered the various proposals for a memoral to the late General Secretary. The recommendations of this committee have gone forward to the Dominion Directors.

It was recommended that a fund of $3000 be raised to provide for an oil painting of Mr. Grindley and the balance to be set aside as a fund, the interest of which would provide an annual award of merit to be given under Grindley's name. The unanimous support of all Directors has been given to the portrait idea and the committee is now in the process of selecting the artist. There is some variation of opinion regarding the type of award of merit to be given and this matter will be discussed further by the committee and probably brought up at the annual convention in Guelph. Announcement of the plans for raising the memorial fund will be made shortly.

Bulletin on Sheep Parasites

Published under the auspices of the Eastern Canada Society of Animal Production.

A bulletin entitled, "Common Animal Parasites Injurious to Sheep in Eastern Canada," has been prepared by Dr. Lionel Stevenson, Ontario Provincial Zoologist, and submitted as a contribution of the Committee on Animal Health. This committee is one of the standing committees of the Eastern Canada Society of Animal Production and consists of Dr. A. E. Cameron, Chief Inspector, Health of Animals Branch, Ottawa; Dr. R. L. Conklin, Macdonald College, P.Q., and Dr. Lionel Stevenson, Ontario Department of Agriculture. The bulletin will prove very useful to extension workers in Eastern Canada. It has been published jointly by the Dominion Department of Agriculture, and the Departments of Agriculture of Quebec, Nova Scotia, and Prince Edward Island. Copies may be secured from these Departments.

Visit Scotland in 1931

A trip to the 100th Anniversary of the Highland Show of Scotland is being conducted by Hon. Duncan Marshall of Cockfield, Brown & Co., Toronto, Canada. The party is sailing on the White Star Steamship Albertic, (19,000 tons) from Montreal, on Saturday, June 13th, 1931, and returning to New York by White Star Motor Vessel Britannic (26,840 tons) on July 26th, 1931. The land portion of the tour is in charge of The Travel Guild of New York and Chicago, with European offices.

The trip, which in point of arrangement and entertainment, is one of the best that has been planned, costs only $750 per person.

Sir Robert Greig head of the Department of Agriculture for Scotland, will join the party in Scotland, and will accompany the visitors through his country and assist in their entertainment. Sir Robert is a very warm friend of Canada, and his company will be greatly enjoyed by the party. Two Governments on the continent have expressed a desire to entertain the party. The Secretary of the Highland Show has already extended a welcome to the visitors on behalf of the Highland and Agricultural Society.

Further information may be secured from the General Secretary of the C.S.T.A., or from Mr. Marshall himself.

Further Plans for Guelph Convention

The President and General Secretary visited Guelph on January 28th and spent the afternoon discussing plans for the eleventh annual convention of the C.S.T.A. with the staff committee and members of the O.A.C. alumni

association. The programme is to remain practically as outlined in last month's note. Several prominent technical agriculturists are to be invited to speak to group sessions and in the open session. It is expected that a Soil Science group will be organized along the same lines as other groups affiliated with the C.S.T.A.

O.A.C. class reunions are to take place on Friday evening, June 26th. Alumni day will probably be Saturday the 27th. Several classes are planning reunions and a large number of graduates will visit the college for the whole week.

The new administration building will be completed by that time. Plastering is well under way now. A visit to this building leaves one with the impression that nothing has been left undone to equip it in a manner entirely suited to the position it will occupy in the life of the college. It will be a commodious residence, an efficient administration building and a comfortable community center. While many may regret the passing of the old halls, the new building has the advantage of modern construction and yet will give the appearance architecturally of having always belonged where it is.

Passing through one section of this building, Dr. Christie remarked, "Here are the bursar's offices, located where they will be most convenient. We have always had trouble to get the boys to find the bursar." Remembering student days, our difficulty was never to find the bursar, but rather the wherewithal.

New Locals to be Organized

As we go to press two new local branches of the C.S.T.A. are under process of organization. A telegram from Calgary informs us of a meeting on February 2nd to establish a branch at that point. This matter was discussed during the western tour of the dominion officers. At Guelph on January 28th the matter of the formation of an O.A.C. local was taken up at a faculty dinner following the convention committee meeting. A committee was appointed to proceed at once with the formation of this branch of the C.S.T.A. Further details of these two groups will be given later.

Quebec Branches of the C.S.T.A. Hold Successful Meetings

During January the Dominion President, Dr. W. T. Macoun, and the General Secretary, visited three of the locals in the Province of Quebec. The first meeting was on January 7th at Ste. Anne de la Pocatière where the staffs of the Agricultural College and the Experimental Farm with other members met for a pleasant luncheon and afternoon visit. Several features of the C.S.T.A. were discussed and advantage was taken of the opportunity to get acquainted.

At Quebec on January 8th a large dinner was given in the Parliament Buildings in honour of the appointment of Hon. Adelard Godbout to the post of Minister of Agriculture. The honorary degree of D.Sc.A. was conferred upon Professor Godbout by the rector of Laval University. Over two hundred were in attendance including most of the Quebec cabinet and members of the legislature. Premier Taschereau and Mr. C. Houde, leader of the opposition, paid their respects to the new Minister and to the technical agriculturists of the province. Dr. Gustave Langelier gave the main address of the evening. Hon. Mr. Godbout was given a great ovation by his con-

fréres and made an exceedingly able speech outlining his policies. Dr. Macoun spoke in French on the work of the C.S.T.A. and was received with great enthusiasm. Mr. Narcisse Savoie acted as chairman and performed the extremely difficult feat of introducing seven speakers and closing a banquet on time. After the banquet a meeting of the Quebec section of the C.S.T.A. was held and the General Secretary took up several matters of interest to the members.

On January 21st the Montreal branch entertained the Quebec Fruit Growers and the Dominion President and General Secretary at a luncheon in the Queen's Hotel. Mr. H. E. Lefévre, French Editor, spoke on his recent trip to Europe and discussed the French section of the magazine. As at the previous meetings, both the President and General Secretary addressed the members in French, congratulating the technical agriculturists of Quebec on the strength of their local C.S.T.A. organizations.

BOOK REVIEW

THE SALT OF THE EARTH—A study in rural life and social progress. R. W. Armstrong, Graphic Press, Ottawa. Price $1.50.

Canadian contributions to the field of rural sociology have been exceedingly rare. If one goes to the library seeking to acquire an understanding of the social problems of rural life he finds shelf after shelf of texts from other countries, but, in many libraries, nothing from Canada. Nor does sociology, as it is sometimes given to us in the form of surveys of seemingly doubtful value, appeal to the average technical man. There is, however, on the part of all those who have the framing of agricultural policies, a desire to understand the farmer.

Toward this understanding, Mr. Armstrong has made a real contribution. A keen student of psychology and economics, he has made the country pastorate his laboratory. As a minister in several urban and rural charges he has studied the skilled labourer and the farmer and the conditions under which they live. Better still, he has put into practice the best recommendations that modern science could give for the betterment of the communities in which he has served.

In manuscript form, these studies were criticized by several of our Canadian psychologists and economists and also stood the test of the searching criticism of the farmers about whom they were written. The present reviewer worked with the author for a number of years and must confess that no Canadian book has sent him searching deeper into what he thought were well grounded opinions about our social structure. If you cannot agree with the author on all his points, you will be doubtful enough about the soundness of your own to do some real thinking on the conclusions which he reaches. Titles of some of the chapters are,—Characteristics of the Rural Mind, The Country Man's View Point, The Farmer's Place in Society, Economic Aspects of the Rural Problem, The Problem of Leadership, and Socializing Country Life.

H.L.T.